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Research for Fabrication of Lithium-Ion Capacitor by Vertical Doping Method and Slurry Pre-Doping Method

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Abstract: A lithium-ion capacitor is called a "hybrid capacitor". It is a new energy storage device that combines the advantages of lithium-ion batteries that have been widely used and electric double-layer capacitors used for energy regeneration and electric power storage of automobiles. As it has not been long since the development of lithium-ion capacitors was started, it is generally difficult to procure them from the market except some overseas and Japanese manufacturers. However, many different varieties of lithium-ion capacitors are expected to be commonly used with the future development of the market. There is a demand for stable power supply through cooperation between the power system and secondary batteries, but lithium-ion capacitors are expected to be adaptable due to their quick response and large capacity. This study opens a new path to the development of lithium-ion capacitors.

Key words: Lithium ion capacitor, slurry coating, pre-doping, vertical doping, porous current collector, lithium metal powder

1. Introduction

Methods for manufacturing lithium-ion capacitors are not open to the public so that we cannot know their details. To manufacture a lithium-ion capacitor, it is essential to pre-dope lithium-ions onto the anode. Combining a lithium-ion pre-doped anode with a cathode of activated carbon will lead to a higher cell voltage than electric double-layer capacitors and larger energy density. This paper reports on the manufacturing processes and operating performance of lithium-ion capacitors by vertical doping method and slurry pre-doping method with lithium metal powder.

2. Basic Composition and Operating Principle of Lithium-Ion Capacitor

Fig. 1 shows the operating principle diagrams of lithium-ion capacitors. Table 1 shows a comparison of the components of three different types of energy storage devices. The principle of a lithium-ion capacitor is shown below [1].

- Charging mechanism

During the charging process, Li^+ ion contained in the electrolytic solution is accumulated and maintained in the negative graphite. This state is called "dope." BF_4^- ion (or PF_4^- ion) that is a negative ion ("anion") contained in the electrolytic solution is absorbed onto the cathode of activated carbon. Then, on the surface of the cathode of activated carbon, BF_4^- ion and positive ion form an electric double layer as an energy storage mechanism (electrostatic phenomenon).

- Discharging mechanism

During the discharging process, Li^+ ion is emitted from the negative graphite into the electrolytic solution, and BF_4^- ion (or PF_4^- ion) is emitted from the cathode of active carbon.

3. Doping Method for Lithium-Ion Capacitor

The methods of manufacturing lithium-ion capacitors are classified into two types depending on the method for pre-doping the anode [2]. Doping

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lithium on an anode with a coating of anode active material applied to the current collector in advance is called “pre-doping”. Pre-doping the anode makes it possible to manufacture a capacitor with a high energy density and also reduce the anode potential and eventually increase the capacitor voltage.

The pre-doping method includes a method of mounting lithium metal foil oppositely to the current collector having a porous structure with a coating of anode active material applied (negative electrode) (called the perforated foil method or vertical doping method; see Fig. 2) and a method of sticking lithium metal foil to the negative electrode having a non-porous structure during the capacitor manufacturing process (called the foil sticking method for horizontal doping method; see Fig. 3).

Horizontal doping methods include an integral mounting employing a nickel metal foil that was developed by the authors [3], and conventional rolling-based methods as well. Vertical doping methods are newer ones that mount a lithium metal foil to the non-coated surface of a current collector of porous structure. To implement them, many of proprietary production technologies and knowhow are needed [4][5].

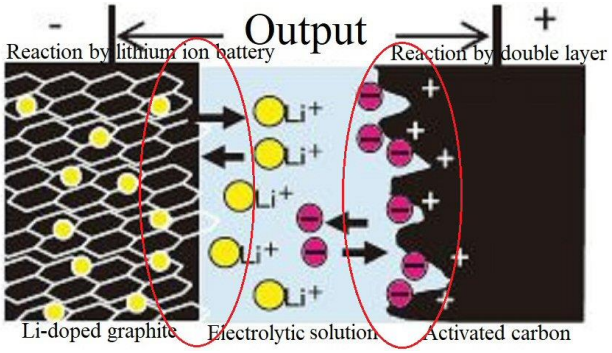


Fig. 1 Principle diagrams of lithium-ion capacitor.

Table 1 Components of energy storage devices.

Type	Positive	Electrolyte	Negative
Lithium ion battery	Lithium cobaltate	Lithium salt (LiBF4, LiPF6)	Graphite
Electric double layer capacitor	Activated carbon	Propylene carbonate type	Graphite
Lithium ion capacitor	Activated carbon	Lithium salt (LiBF4, LiPF6)	Lithium-dopable carbon material

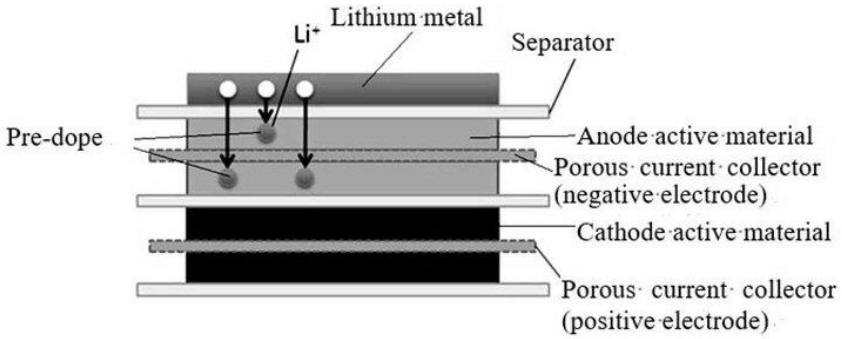


Fig. 2 Image of vertical doping.

Fig. 3 Image of horizontal doping.

With electrolyte injected, the lithium metal foil emits lithium-ions which in turn move to the anode active material coated on the surface of the anode through the pores in the current collector. This is the mechanism of lithium-ion doping that occurs in the vertical doping method. For this study, two types of porous current collectors were used in this study. Prototype 1 used copper foil of 10 μm thickness, 0.4 mm pitch, hole 100 μmφ, and prototype 2 used copper foil of 10 μm thickness, 0.1 mm pitch, hole 20 μmφ. The copper foil of Prototype 1 is shown Fig. 4.

4. Assembling Methods for Lithium-Ion Capacitors (Prototype 1)

First, a negative electrode sheet was manufactured by applying an active material consisting mainly of graphite. Specifically, the porous-structured current collector (copper foil) shown in Fig. 4 above was coated with a slurry of active material. Table 2 shows the composition of the active material. Before coating the current collector, the non-coated surface was masked by taping to prevent the slurry from permeating onto it.

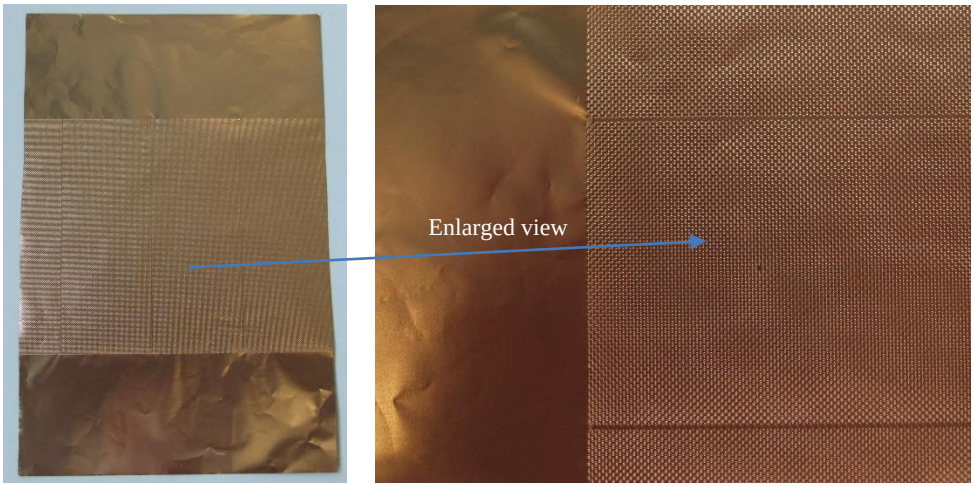


Fig. 4 Current collector of porous structure (copper foil).

Table 2 Composition of the slurry of active material.

Constituent	Weight (g)
Graphite	22.5
Conductive carbon (SUP-P)	0.5
Binder (PVDF)	2.0
Electrode liquid (NMP)	20.2
Weight total	45.2

Fig. 5 shows the coating process using a semi-automatic coating device. Fig. 6 shows the negative electrode sheet as coated. Fig. 7 and Fig. 8 show the sheet before and after the masking tape is removed.

The positive electrode sheet (Table 3) is a sheet coated with an active material of activated carbon on both surfaces, by courtesy of a company who supports our research.

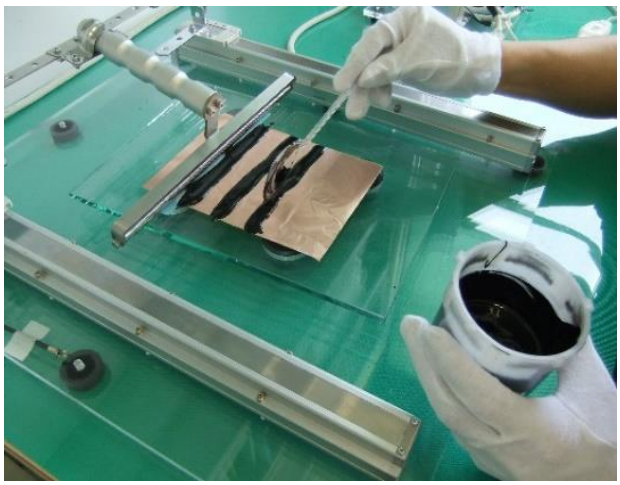


Fig. 5 Application using a coater.

Fig. 9 shows the configuration and dimension of the negative and positive electrode sheets and the lithium metal foil used for pre-doping the anode. Two lithium

Fig. 6 Anode and cathode sheets after coating.

Fig. 7 Pasting work the masking tape onto the current collector before coating.

Fig. 8 Coated surface before and after the masking tape is removed.

Table 3 Composition of the slurry of active material.

				Coarting (unit: um)				
Item	Active material	Coating conditions	Total thickness	Coating thickness	Current collector thickness	Current collector	Size	Uncoated surface
Positive electrode sheet	Activated carbon	Both sides	18	2	16	Aluminum foil	26 cm width, 80 m roll length	Both size 2 cm

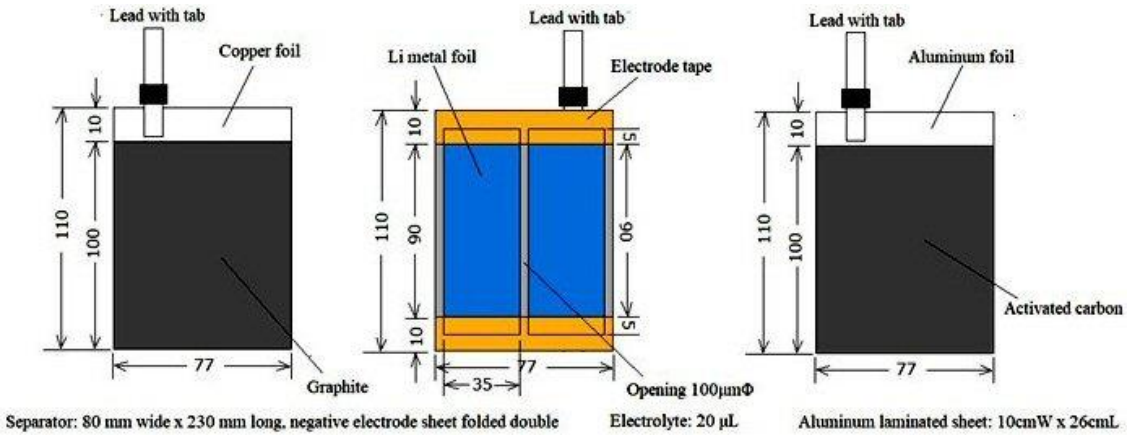


Fig. 9 Configuration of lithium metal foil and dimension of negative and positive electrode sheets.

metal foils (each 35 mm wide × 100 mm long) were fastened to the non-coating — opposite — surface of the current collector by taping.

To compare the characteristics of the cell with pre-doping, those having the same dimension but without lithium metal foils for pre-doping were manufactured using a normal current collector, that is, a collector of non-porous structure (copper foil of 9 mm in thickness), unlike the collector of porous structure for the lithium-ion capacitor under discussion here. Fig. 10 shows the negative and positive electrode sheets with a tabbed lead fastened by spot welding. Operations of assembling lithium metal foils to the current collector, injecting electrolyte and encapsulating the assembly in the cell were performed in a vacuum glove box. Fig. 11 shows the manufactured capacitor cells with and without pre-doping the anode.

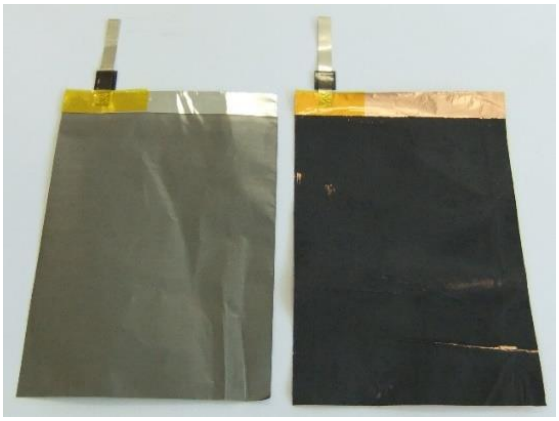


Fig. 10 Negative and positive electrode sheets each with a tabbed lead.

Fig. 11 Lithium ion capacitors manufactured.

5. Assembling of Prototype 2

The device configuration produced is shown in Fig. 12. The coating method of the active material slurry (graphite) on the negative electrode current collector is the same as in trial prototype 1.

The positive electrode current collector is sandwiched with the separators, and the porous structure current collectors are stacked in a sandwich form from both sides of the positive electrode current collector, and two lithium metal foils (40 mm×40 mm) are formed on the opposite surface of the porous structure current collector. After applying the active material slurry to the porous structure current collector, a masking tape is attached, and the cell is assembled as an electrode body in which the positive electrode current collector is sandwiched by the separator (Fig. 13). The assembled electrode body before the lithium metal foil is attached is shown in Fig. 14.

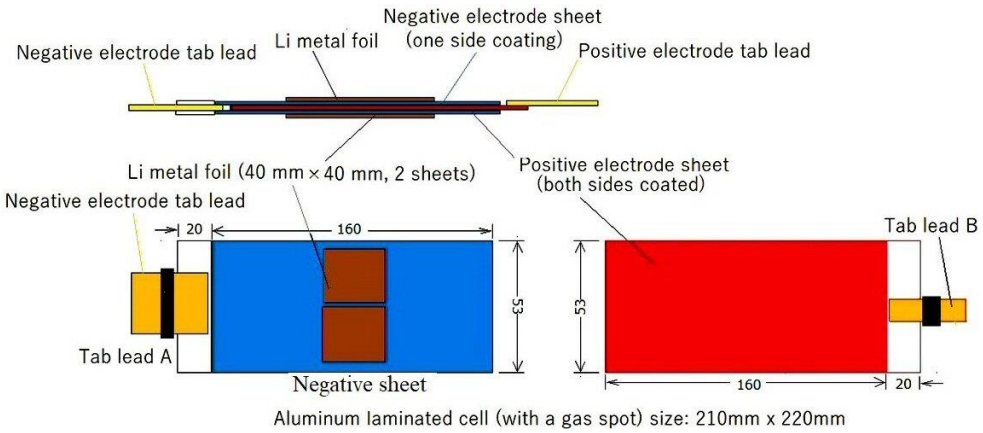


Fig. 12 Cell Device configuration of prototype 2.

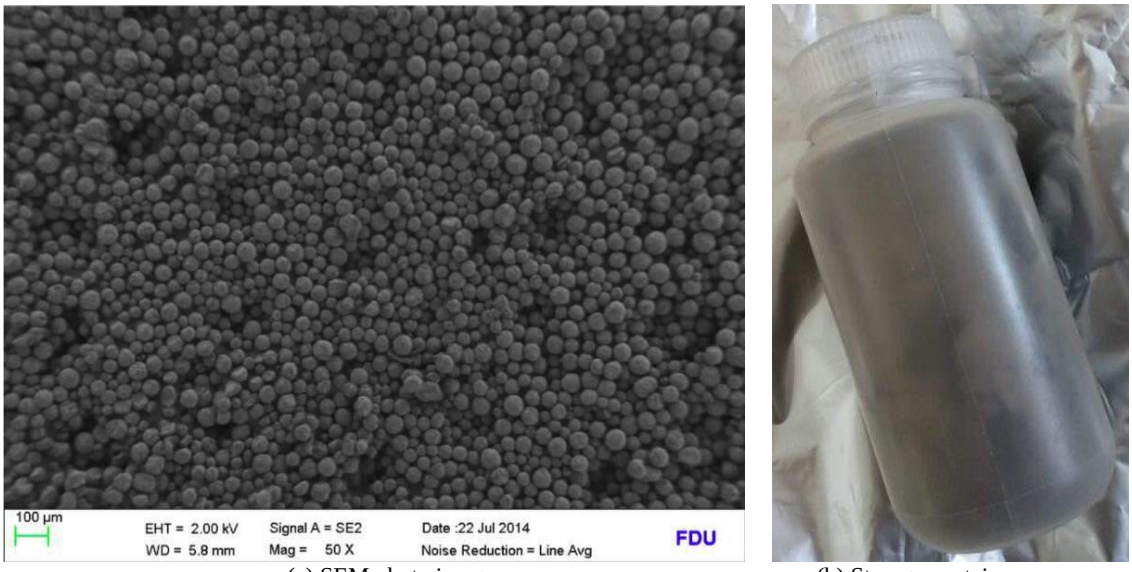
Fig. 13 Assembling electrode body with separator.

Fig. 14 Electrode body before sticking lithium metal foil.

6. Pre-doping Method Using Lithium Metal Powder (Prototype 3)

As a new lithium doping method, a small amount of lithium metal powder with a fine and uniform particle diameter is mixed into the active materials without stirring against the lithium metal foil as shown in the vertical doping method. The making of a slurry is attempted by stirring and mixing with the active materials and lithium metal powder. This doping method was named “slurry pre-doping method”.

A lithium metal powder with a particle size of 10 μmφ and a purity of 99.5% is used for the trial production (Fig. 15).



(a) SEM photo image (b) Storage container

Fig. 15 Lithium metal powder.

In the process of manufacturing the negative electrode active material slurry, as a result of trial and error, 0.1 g of lithium metal powder was mixed into the active material shown in Table 2 to make an active material slurry, and the active material slurry was coated on both sides of the current collector. The component ratio of the active material is the same as in Table 2. The mixing and stirring work from the measurement of the weight of the lithium metal powder is performed in a vacuum glove box (Fig. 16 and Fig. 17). The size of the current collector was the same as that of prototype 2 for the purpose of property evaluation comparison.

After slurry coating, baking was performed, and an electrode body was assembled by a winding method [5]. After setting the electrode body in the pouch cell,

Fig. 16 Weight measurement of lithium metal powder.

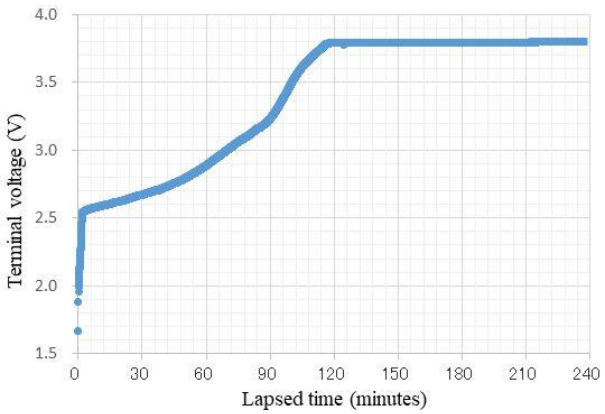
Fig. 17 Mixing and stirring work by planetary system.

an electrolytic solution was injected in a vacuum glove box to complete the cell. The method of assembling a cell using a porch cell is basically the same as that of prototype 2.

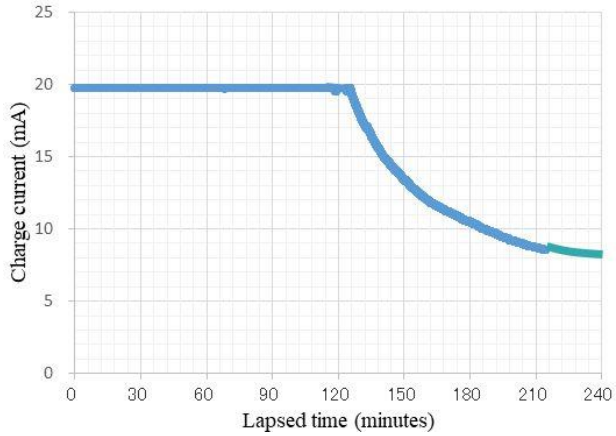
7. Evaluation of Charge and Discharge Characteristics of Lithium-Ion Capacitor

To accelerate pre-doping, the cells manufactured were initially charged after a lapse of one day (being left not charged at room temperature) at room temperature after manufacture to simulate its aging. Fig. 18 shows the charge characteristics of the cell (prototype 1) for CCCV (20mA/3.6V).

Fig. 19 shows comparison between the cell with pre-doping and that without pre-doping with respect to discharge characteristics at discharge current of 1mA, 2mA, 3mA and 4mA. They are significantly different in discharge characteristics.

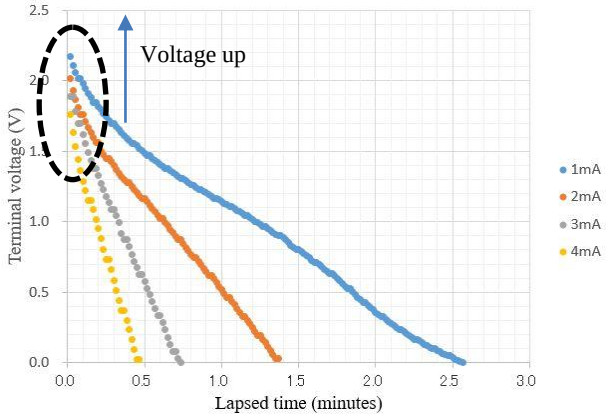


(a) Charge voltage

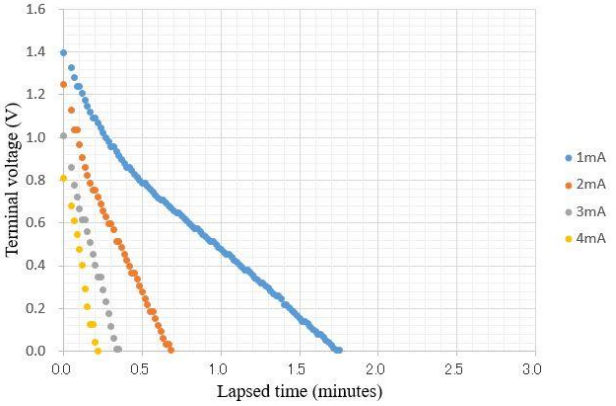


(b) Charge current

Fig. 18 Initial charging characteristics of prototype 1.



(a) Pre-doped



(b) Un-doped

Fig. 19 Difference between pre-doped and undoped discharge characteristics.

Fig. 20 shows measurements of discharge characteristics of a seven-days-old cell. Compared with the one-day old cells, the voltage at which discharge begins was higher.

The discharge characteristics at discharge currents of 3 mA, 4 mA and 5 mA of prototype 2 are shown in Fig. 21. As compared with the discharge characteristics of the same discharge current in Fig. 18 and Fig. 19 in the case of production 1, it can be confirmed that the terminal voltage in the case of prototype 2 increases by about 40% and the discharge time is extended by about 6 times.

The prototype 2 of the structure in which two porous structured current collectors were sandwiched from both sides of the positive electrode current collector and lithium metal was attached from both sides was able to dope Li ion more effectively than the prototype 1.

Next, Fig. 22 shows the discharge characteristics of prototype 3 by the slurry pre-doping method using lithium metal powder. The discharge capacity (discharge duration) and terminal voltage can be greatly increased as compared with the discharge characteristics of the un-doping sample.

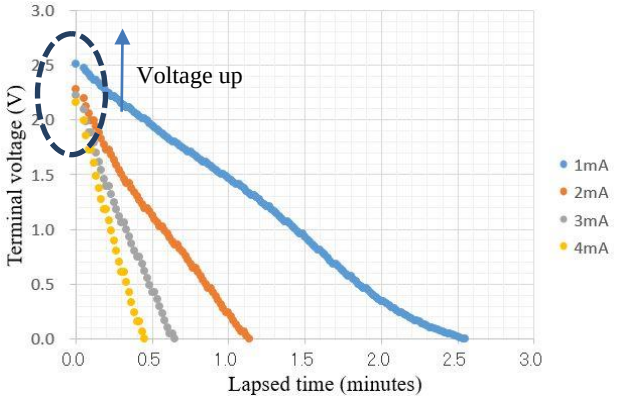


Fig. 20 Discharge characteristics when left for 7 days.

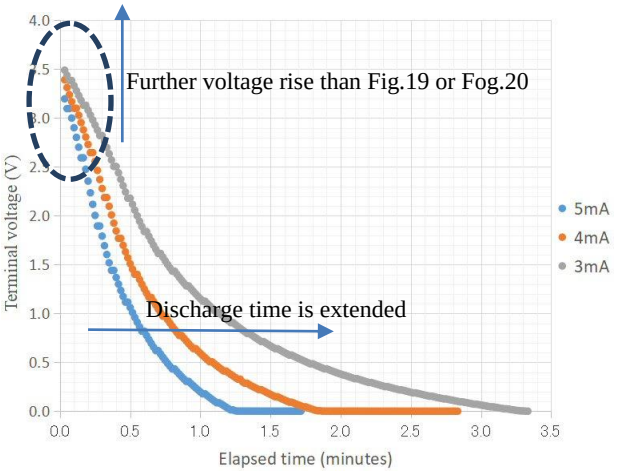


Fig. 21 Discharge characteristics of prototype 2.

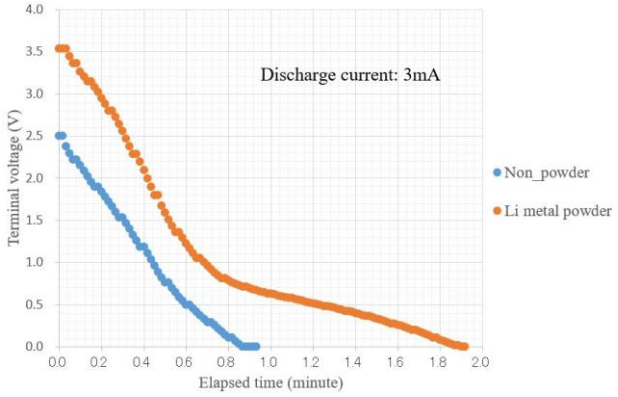


Fig. 22 Discharge characteristics of prototype 3 by slurry pre-doping method.

8. Conclusion

A lithium-ion capacitor with a lithium metal foil stuck to the current collector of porous structure by vertical doping was manufactured. Findings obtained to date and challenges are shown below.

(1) The difference between the horizontal and vertical doping methods could be clarified through prototype manufacture. Both methods have advantages and disadvantages and require skill in manufacturing the cells successfully.

(2) As a result of preparing a series of slurry of anode active material each having a different mixing ratio of anode active material, the mixing ratio shown in Table 2 was found the most effective for obtaining the best performance of the slurry.

(3) Coating a porous material of current collector with a slurry may give rise to irregularity in coating compared to non-porous current collectors. To avoid this, it is necessary to adjust or modify the coating method. The masking tape applied may cause the current collector to deform. This should also be remedied.

(4) A sandwich structure of lithium-ion capacitor by vertical doping methods could be manufactured successfully.

Prototype 1: effective area of 100 mmL × 77 mmW

Prototype 2: 160 mmL × 53 mmW

(5) Comparing the lithium-ion capacitor with a configuration of pre-doping the anode with a counterpart having the same dimension but without pre-doping showed that the former has a higher terminal voltage so that the discharge time can be made longer. This evidences that pre-doping is effective.

(6) A lapse of longer time after pre-doping led to doping progressing more rapidly. About this, we would like to confirm this tendency by increasing the number of trial cells in the future.

(7) The prototype 2 of the structure which sandwiches two porous structure current collectors from both sides of the positive electrode current collector was able to make the terminal voltage and the discharge time greatly increased. It was confirmed that Li ions can be doped more effectively than in prototype 1.

(8) The slurry pre-doping method has many problems in the future, such as examination of the particle size of lithium metal powder and the weight ratio with other active materials when preparing the slurry. However, it was confirmed by experiments that both of discharge capacity and terminal voltage were increased at least as compared with the un-doping sample.

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Insolation Periods of Climate Change as a Means of Solving Long-Term Climatic Puzzles

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Abstract: The results of the new Astronomical theory of climate change are considered. Earth insolation depends on the eccentricity of the Earth's orbit, the position of the perihelion and the inclination of the equator to the orbit. Changes in these three parameters are shown for time of 5 million years ago. A change in the insolation of the Earth over 1 million years is considered, and the results are compared with the previous theory. It is shown that the change in insolation in high latitudes from the cold to the warm epoch changes in twice. Insolation periods of climate change have been introduced. They coincide with the known warming and cooling of the paleoclimate. The geography of the onset and end of polar days and nights in different epochs is considered. The presented results are a reliable means of solving the paleoclimate puzzles associated with its long-period changes.

Key words: earth, orbit, axis, evolution, insolation, paleoclimate, periods

1. Introduction

Many processes on Earth, including weather and climate, are determined by the heat of the Sun. Day is replaced at night due to the rotation of the Earth around its axis. Winter comes to replace summer, because the Earth is orbiting around the Sun and its axis inclines to the orbit's axis of the angle 23.4°. Because of these movements, the length of the day along the latitude of the Earth varies from 24 hours to the polar night.

The orbital and rotational movements of the Earth create the contemporary climate on the Earth. However, the parameters of these movements change over the times of tens thousands years and the climate becomes other. For example, the angle of inclination between Earth's equator and its orbit, i.e., obliquity, varies from 14.4° to 32.4°. With a small angle of obliquity it is observed a cooling at high latitudes, and with a large angle the warming occurs. For example, 32.28 thousand years ago (ka) with an angle of 32.1° the heat per year at high latitudes is twice more than 46.44 ka at the angle of 14.8°. In these two epochs, in the summer half of the year also doubles the heat more at high latitudes.

However, in equatorial latitudes, the changes are completely different and even reverse in direction. For example, in the warm epoch of 32.28 ka the annual heat is less by a quarter than in the cold epoch of 46.44 ka. In such cold epochs, as 46.44 ka, at latitudes of 53.4° and more the heat in the summer half year is less than now at the pole. Therefore, the snow does not melt over the summer, and in such cold epoch the ice cover forms in high latitudes, i.e., the ice age comes.

What are interesting are the winters in the Ice Ages. They are warmer around the globe than during the warm period. The warm winters, the warm oceans in winter it is lead to an increase in snow precipitation, which further contributes to the growth of ice caps.

And in the warm epochs, for example 32.28 ka in the summer half year, even at a latitude of 80°, there is more heat than now at the equator. Therefore, all ice

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sheets on the continents are disappearing, and in Greenland and Antarctica they are greatly reduced. At the same time, winters are cold, so little falls during the winters, and glaciers are not restored.

What is interesting is the polar circle. In the warm epoch, it descends to the latitude of the Tyumen, i.e. polar days and polar nights come here, and at the same time it is warmer in summer than at the equator. That is, the Earth's climates are becoming others, and such that no one could even imagine.

Therefore, it becomes clear why the past of the Earth consisted of a number of puzzles, for the solution of which the researchers put forward as many presumptions and hypotheses as there were the researchers. New Astronomical Theory puts an end to these hypotheses [1-2]. All extremums of insolation are timed to within a few minutes and for 200 ka numbered. Insolation periods of climate change are defined. They coincide with paleoclimate changes according to its study for 50 thousand years. Therefore, the insolation periods are a reliable means for solving long-term climatic puzzles.

The results of the new Astronomical theory of climate change are mentioned above. The former Astronomical theory was developed by the Yugoslav scientist Milutin Milankovich almost 100 years ago [3-4]. It is also called the Milankovitch's theory or the Orbital theory of the paleoclimate. Over the years, this theory has been repeated by many researchers [5-9], but they were based on the same principles as M. Milankovich.

Astronomical theory of climate change includes a number of complex problems: the evolution of the Earth's orbital motion, the evolution of the Earth's rotational motion, changes in solar heat on the Earth's surface depending on these movements, and other problems. In our works [1, 10-18], all these problems were solved in a new way, starting with the derivation of equations, the creation of new methods for solving differential equations, and the analysis of the solution results. This led to new results that are consistent with a change in the paleoclimate.

Next, we consider some of these results.

2. Earth's Motions and Their Variations

The Earth moves along an elliptical orbit around the Sun, which is located at the focus of the ellipse (Fig. 1). The shortest Earth-Sun distance in perihelion is denoted as R_p, and the largest distance in aphelion, as R_a. The period of Earth's motion with respect to the motionless space connected with the Solar system is P_{sd} = 365.25636042 days. The quantity P_{sd} is called the sidereal orbital period of the Earth's motion around the Sun. The Earth's orbital motion proceeds in anticlockwise direction on the condition that the orbit is viewed from the Earth's North Pole *N*. The normal to the orbital plane is denoted as $\vec{S}$, and it is called the orbital axis.

With respect to the motionless space, the Earth rotates around its axis $\vec{N}$ at an angular velocity ω_E = $7.292115 \cdot 10^{-5}$ 1/sec in anticlockwise direction coincident with the direction of the Earth's orbital motion. The value of ω_E corresponds to a full revolution performed by the Earth in 0.99726968 day. The Earth's rotation axis $\vec{N}$ is inclined to the orbital axis $\vec{S}$ at an angle equal in the contemporary epoch to ε = 23.44°. This inclination is called obliquity. During the orbital motion of the Earth, the orientation of its rotation axis $\vec{N}$ remains unchanged in space (Fig. 1). That is why at two points of the orbit at times March, 20 (20.03) and September, 22 (22.09) the axis $\vec{N}$ turns out to be normal to the Earth-Sun direction, so that with respect to the Earth the Sun is in the equatorial plane of the Earth. That is why the southern and northern hemispheres receive identical amounts of solar radiation and, in its duration, the day appears to be equal to the night. These points are called the day of vernal equinox (20.03) and the day of autumnal equinox (22.09). At the time of June, 21 (21.06), the axis $\vec{N}$ is least inclined to the Earth-Sun line, and the northern hemisphere at that time is therefore illuminated with solar radiation to a largest degree. At

the time of December, 21 (21.12), the axis $\vec{N}$ is most inclined to the Earth-Sun line; that is why the southern hemisphere at that time is the most illuminated one, and at the high latitudes of the northern hemisphere there comes a polar night. Since the two situations of extreme angles, with the times spent on reaching and leaving the extreme angles, last for several days, those points are called respectively the summer solstice day (21.06) and the winter solstice day (21.12).

The inclination of the Earth axis $\vec{N}$ to the orbital axis $\vec{S}$ leads to the variation of sunshine duration both during the year and on one and the same day at different latitudes. On summer solstice day (Fig. 1, 21.06), we have a polar day in the whole region between the North Pole and the Arctic Circle. Then, as the latitude decreases, the day gets shorter to reach 12-hour duration at the equator, and we have a polar night established below the Antarctic Circle. On the contrary, on the winter solstice day (21.12), on the territory between the North Pole and the Arctic Circle we have a polar night; then, the day starts increasing in duration. At the equator, the day lasts for 12 hours, and a polar day sets in below the Antarctic Circle. As we approach the equinoctial points of 20.03 and 22.09, the difference between the days in latitude decreases in value, the day's duration along all latitudes becomes identical, equal to 12 hours.

As the Earth moves along its orbit, the alteration of seasons occurs. The duration of the seasons is defined by the Earth's motion along its orbit over certain orbital segments. Over the segment from the vernal equinox day, 20.03, till the summer solstice day, 21.06, the duration of spring is 92.7 days. Over the *summer* segment, the summer duration is 93.7 days. Over the *autumnal* segment, the autumn duration is 89.9 days. Over the *winter* segment, the duration of winter is 89.0 days.

The Earth's orbital and rotational motions define the variation of the Earth's climate in the contemporary epoch. However, those motions vary in time, and the Earth's climate therefore undergoes changes. The position of Earth's orbit precesses in space. The Earth orbit's axis $\vec{S}$ (Fig. 1) rotates or, in other words, it precesses about the direction of $\vec{M}$, which is motionless in space. The precession proceeds clockwise with a period of 68.7 thousand years. Also in clockwise direction, the Earth's axis $\vec{N}$ precesses about the direction of $\vec{M}_2$, also motionless in space. The precession period here is 25.74 thousand years. Besides, the axes $\vec{S}$ and $\vec{N}$ execute oscillations, each with respect to its own precession axis, $\vec{M}$ and $\vec{M}_2$, respectively. In addition to those motions, the shape of the orbit, that is, its eccentricity $e = (R_a - R_p)/(R_a - R_p)$, whose value varies from 0 to 0.064 at the current value being equal to $e = 0.016$ and, also, the perihelion position, both undergo variations. Today, the perihelion is over the *winter* segment (Fig. 1), when the winter sets in the Northern hemisphere. Since the Earth orbit' perihelion rotates in anticlockwise direction at a mean period of $T_p = 147$ thousand years, its position in other epochs can be at any point of the Earth's orbit. Here, T_p is a period of the perihelion rotation relative to the motionless space.

3. Evolution of the Parameters of the Orbit and the Axis of the Earth

The amount of heat coming from the Sun to Earth, i.e., the Earth's insolation depends on the three parameters of its orbital and rotational motions, e, $\varphi_{p\gamma}$, and ε. The evolution of those parameters is shown in Fig. 2. Over this time interval, the eccentricity e oscillates within the range from 0.0022 to 0.0629 with oscillation periods of 94.5 thousand years, 413 thousand years, and 2.31 million years. The perihelion angle $\varphi_{p\gamma}$ varies from 1.776 radian in the epoch of 12.30.1949 to (-1445.7) radian in the epoch of five million years ago. This change is due to the rotation of perihelion in the direction of Earth's orbital motion.

Fig. 2 shows the moving average values of the periods $T_{p\gamma t}$ of perihelion rotation over intervals of 20 thousand years. Evidently, the rotation periods are distributed unevenly, they vary from 13.8 to 41.8

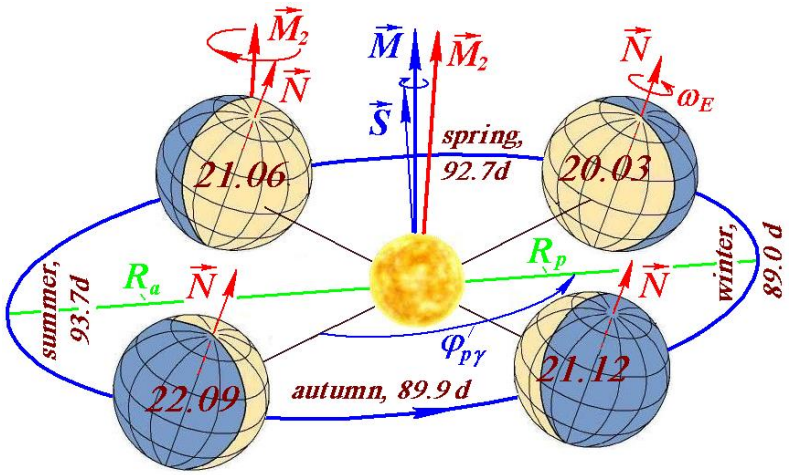

Fig. 1 The Earth's position in its orbit in 2025 at the days of vernal equinox (*20.03*), summer solstice (*21.06*), autumnal equinox (*22.09*), and winter solstice (*21.12*), and the time expressed in the Earth motion's days in spring (*92.7 d*), in summer (*93.7 d*), in autumn (*89.9 d*), and in winter (*89.0 d*): $\vec{N}$ is the Earth's rotation axis; $\vec{M}_2$ is a vector relative to which the axis $\vec{N}$ precesses at a period of 25.74 thousand years; $\vec{S}$ is the Earth's orbit axis; and $\vec{M}$ is a vector relative to which the axis $\vec{S}$ precesses at a period of 68.7 thousand years; obliquity is an angle between axes $\vec{N}$ and $\vec{S}$; $\varphi_{p\gamma}$ is an angle between autumnal equinox and perihelion [1, 18].

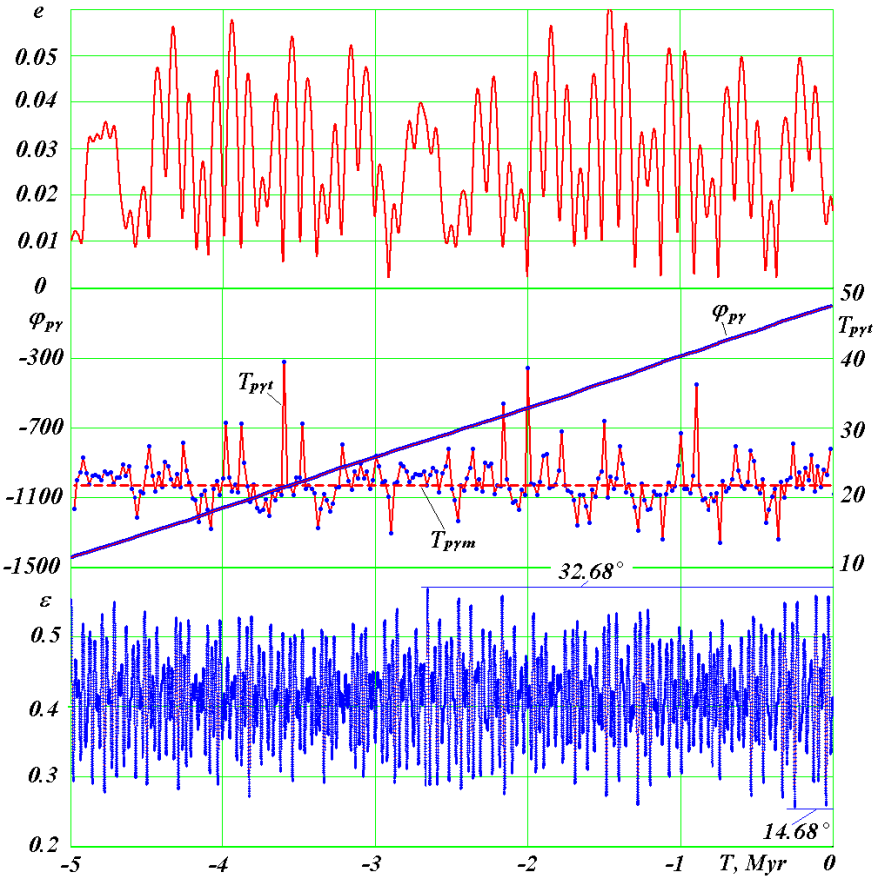

Fig. 2 Evolution of eccentricity *e*, perihelion angle $\varphi_{p\gamma}$, and obliquity ε over the last five million years: $T_{p\gamma t}$, in thousand years, is the moving average value of the period of perihelion rotation over 20-thousand-year time intervals; $T_{p\gamma m}$ = 21.7 thousand years is the mean period of perihelion rotation.

thousand years. On the average, those changes occur once in a time interval of 19 to 25 thousand years. The average period of perihelion rotation over five million years is T_{pym} = 21.7 thousand years.

The oscillations of the obliquity ε proceed irregularly and with different amplitudes (Fig. 2). The main oscillation period, the average one over the time interval of five million years, is $T_{\varepsilon m}$ = 25.73 thousand years. Taking into account the use of different averaging algorithms, this period is equal to the period of Earth-axis precession P_{pr} = 25.74 thousand years. The period of oscillation in a particular epoch may differ from the mean oscillation period by a thousand years. Also, there may be more significant differences. For example, in the epoch of 4.6 million years ago one minimum of ε turned degenerated, and two oscillations occurred over the three intervals of $T_{\varepsilon m}$, i.e., the oscillation period here becomes equal to 38.6 thousand years. The amplitude of the oscillations of ε is variable; it varies from zero to a maximum value equal to 9°. On the average, the oscillation amplitude of ε is 2.74°, and the average value of the obliquity is 23.8°, with its current value being equal to 23.44°.

Over the interval of five million years, there are no time intervals with repeating behavior of the changes in angle ε. The distribution of large fluctuation amplitudes is also irregular. There are two time intervals with very large amplitudes: 0 to 0.25 and 2.2 to 2.8 million years ago. Also, there are time intervals with very small fluctuation amplitudes, for example, in the epochs of $T \approx 3.3$ million years ago and $T \approx 4.2$ million years ago. The largest value ε = 32.68° is shown in Fig. 2 in degrees during the epoch T = 2.6582 million years ago, and the smallest one, ε = 14.68°, in the epoch T = 0.2508 million years ago. Thus, the largest amplitude of Earth-axis oscillations over the last five million years amounts to $\Delta\varepsilon_{Amx}$ = 9°.

4. Evolution of the Earth's Obliquity and Insolation Over A Span of 1 Million Years

In Fig. 3, the results of the new Astronomical theory of climate change *1* are compared with the results of the previous theory *2* [9], for obliquity ε and summer insolations: Q_s^{65N} and *I*. Over the time interval of 1 million years the oscillations of ε as yielded by the new theory *1* proceed in the range from 14.7° to 32.1°, whereas the range in the previous theory was from 22.08° to 24.45°; in other words, the range of oscillations in the new theory proves to be seven times greater.

This difference is due to the fact that, in the new Astronomical theory, the Earth's rotation problem was treated in full, without simplifications. The solution of this problem and various checks of obtained data were analyzed at length in publications [1, 15, 19].

The astronomic summer and winter half-years measured from the vernal equinox day to the autumnal equinox day and vice versa differ in duration for different epochs. That is why it is caloric half-years, equal in duration, that are considered here. The summer insolation Q_s^{65N} occurring during the summer caloric half-year at the 65-deg northern latitude is a characteristic of the Earth's climate when considering climate change over time. Fig. 3 gives a comparison of the insolation changes Q_s^{65N} in the new theory (line *1*) [1] with the changes as calculated by the previous theory (line *2*) [9]. As it is seen, the amplitude of insolation oscillations is also seven times greater than that in the previous theory. Besides, the insolation extremes occur at other times, and the oscillation periods are different. Therefore, the previous theory could not explain the significant changes in the Earth's climate that had been occurring in the past.

In order to compare climates in other epochs with the contemporary climate, we consider the insolations in equivalent latitudes *I*. For calculating of *I*, we consider the Earth's latitude φ in contemporary epoch characterized by the admission of the same amount of summer solar radiation Q_s at the latitude 65°*N* in other epoch. Fig. 3 shows the summer insolation in equivalent latitudes *I* over a time interval of 1 million years. The lowest values $I \approx 90°$ indicate that at the

latitude 65°*N* in summertime there was less solar radiation than now on the pole. The highest values such as $I \approx 23°$ at time -0.031 million years denote epoch in which in summertime the amount of the solar radiation having reached the Earth at the latitude 65°*N* exceeds the amount of solar radiation having fallen onto it presently at tropics, i.e., in the equatorial area. Such profound insolation oscillations lead to substantial climate oscillations. As it is seen from graph *2*, the oscillations of *I* in the previous theory were less significant. That is why the previous theory could not explain the paleoclimate fluctuations.

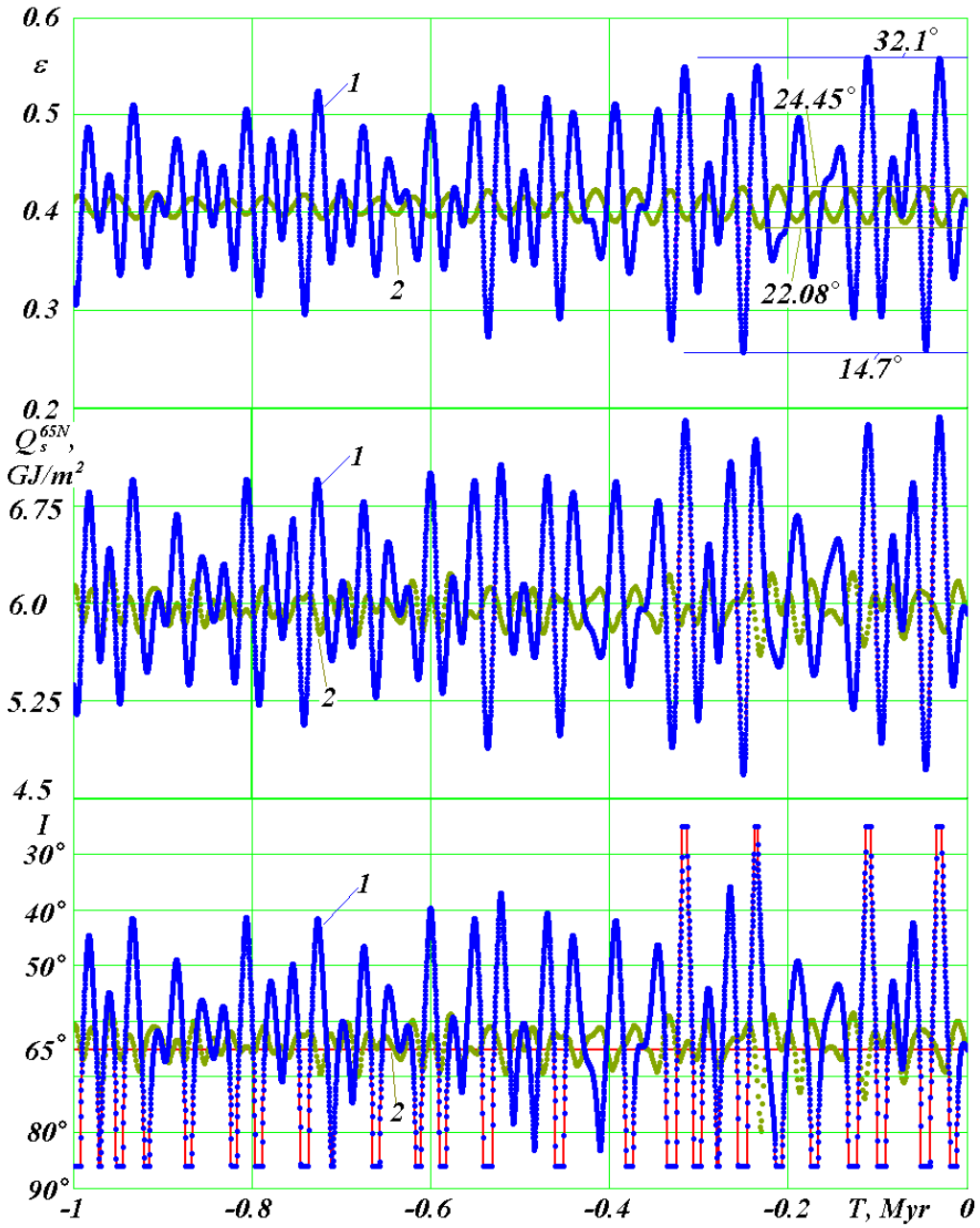

Fig. 3 Evolution of the obliquity *ε*, and that of summer half-year insolations Q_S^{65N} and *I* over a time interval of 1 million years. Comparison of results yielded by new Astronomical theory of climate change (line *1*) with the results of the previous theory (line *2*) demonstrated using, as an example, the work by J. Laskar *et al.* [9]. Q_S^{65N} – insolation in GJ/m² over the summer caloric half-year at 65-deg northern latitude; *I* – insolation in the equivalent latitudes over the summer caloric half-year at 65-deg northern latitude. Indicated in degrees are the maximum and minimum values of *ε*.

5. Variation of Insolation Over the Earth's Latitude

Fig. 4 shows the variation of the annual insolation Q_T, and insolations during caloric half-years summer Q_s, and winter Q_w over the latitude φ in three epochs: in contemporary epoch $T = 0$, in the warmest epoch $T =$ -31.28 kyr, and in the coldest epoch $T =$ -46.44 kyr (the warmest and the coldest epochs over a time interval of 200 thousand years) [1]. Those epochs are characterized by the following values of 65°N summer insolation: $Q_s^{65N} = 5.9$, 7.4, and 4.7 GJ/m^2, respectively. In those epochs, the obliquities were $\varepsilon = 23.44°$, 32.10°, and 14.8°, respectively.

Summer insolation Q_s (dashed lines in Fig. 4) in the contemporary epoch (line *1*) has minimum values at the poles, reaches a maximum value at the tropics $\varphi = \varepsilon$, and attains a minimum value near the equator. Summer insolation Q_s at the poles in the warm epoch (line *2*) increases compared with the cold epoch (line *3*) by a factor of 2.07. At 65°N, this insolation changes 1.57 times. Since, on the average, the latitude 65°N adequately represents the change in insolation at high latitudes, it was accepted by M. Milankovitch [4] as a reference one for climate characterization. In the warm epoch *2* insolation Q_s attains an equatorial minimum in Southern Hemisphere, and in cold epoch *3*, in Northern Hemisphere.

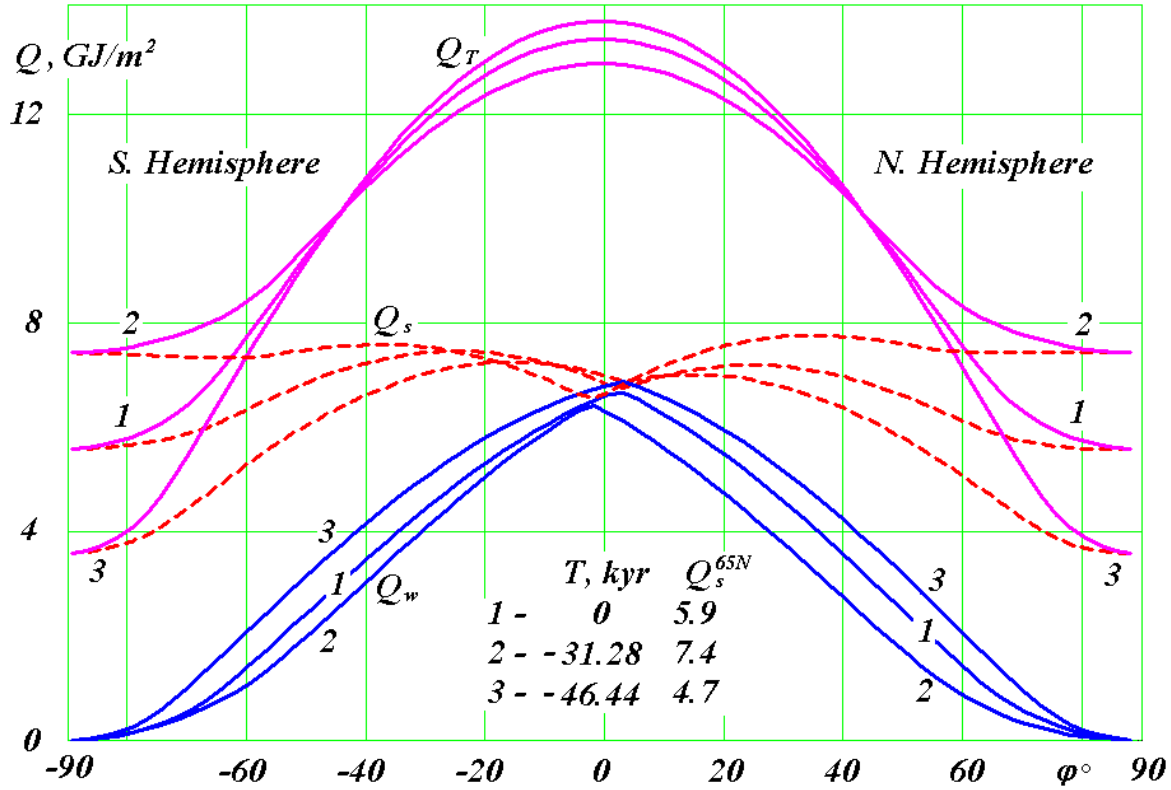

Fig. 4 The distribution over latitude φ of summer Q_s, and winter Q_w half-years, and of annular Q_T insolations for three epochs: *1* – contemporary epoch; *2* – warmest epoch; *3* – coldest epoch over a time interval of 200 thousand years; *T*, kyr – time in thousand years reckoned from December 30, 1949.

The winter insolation Q_w (Fig. 4) on the poles is zero, and it monotonically increases in the equatorial region. In the equatorial region, the insolation Q_w exhibits a maximum at a latitude φ at which the summer insolation Q_s shows a minimum. Over the period from cold epoch *3* to warm epoch *2*, the winter insolation Q_w exhibits most pronounced variations at middle latitudes. In the latter situation, for epochs *2* and *3* under consideration, e.g., at the latitude $\varphi = 40°$, the change of the winter insolation is 1.38 times greater in the

northern hemisphere in comparison with the southern hemisphere. In cold epoch *3*, the winter insolation at all latitudes is greater than that in warm epoch *2*. In other words, during the cold epochs the winter seasons are warmer than those during the warm epochs.

The annular insolation Q_T (Fig. 4) monotonically increases from the poles toward the equator. At the equator, the annular insolation exhibits a maximum, with the annular insolation being symmetrical with respect to the equator. In other words, the amounts of heat per year are identical in both hemispheres. From cold epoch *3* to warm epoch *2*, the annular insolation Q_T on the poles increases by the same factor the summer insolation Q_s does. With decreasing latitude, the difference between the annular insolations decreases, and at the latitude φ = 45° the annular insolation experiences no changes. In the equatorial region, the changes of Q_T are reciprocal to its changes at the high latitudes: in cold epoch *3*, the amount of heat per year exceed that in the warm epoch. In the latter situation, the change of insolation Q_T is four times smaller than that in the high-latitude region. That is why the main changes of the annular insolation occur at high latitudes.

6. Periods and Gradations of Earth's Climate Changes

Over the previous interval of 200 thousand years (see Fig. 5), 13 climatic periods, O_I, 1_I, 2_I, , , 12_I, were identified [1, 16, 17]. As a result of the comparison of these periods with paleoclimate data for Western Siberia over 50 thousand years, it was found that the periods 3_I, 2_I, 1_I, O_I (see Table 1) refer respectively to the Ermakov ice age, Karginsky warming, Sartan glaciation, and Holocene optimum. They coincide with periods of paleoclimate change in the works of Arkhipov [20], Groswald [21], Svendsen et al. [22] and others. Those evens also correspond to ice ages and interglacial periods in Europe and North America. For example, period 1_I corresponds to Upper Würm, Upper Weichselianan the Ostashkov ice age in Europe and Upper Wisconsinan in North America.

Also, the following gradations of the warm and cold climate were introduced (Fig. 5): moderately warm, warm, and extremely warm climate levels, and moderately cold, cold, and extremely cold climate levels. During the past period of 1 million years (see Fig. 6), the Earth has experienced six extremely cold (e.c.) periods and four extremely warm (e. w.) periods.

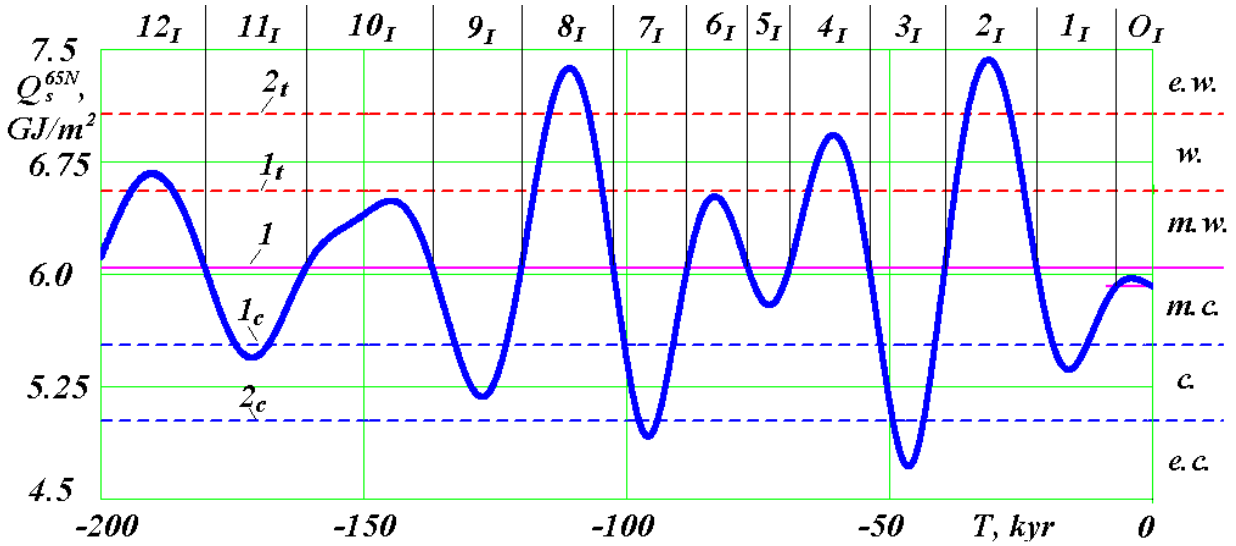

Fig. 5 Insolation periods O_I, 1_I, 2_I,… 12_I over a time interval of 200 thousand years and their boundaries: *1* – mean insolation Q_{sm}; *1t* and *2t* – the first or second boundaries of warm levels; *1c* and *2c* – the first and second boundaries of cold levels; m.w., w., e.w – moderately warm, warm, and extremely warm levels; m.c., c., e.c. – moderately cold, cold, and extremely cold levels.

Table 1 The extremes of insolation for 50 ka: O_I, 1_I, 2_I и 3_I are the insolation periods. The warming is marked as maximum (max), and cooling – as minimum (min).

Parameters	Values in different epochs			
Extremes: T, ka.	4.16	15.88	31.28	46.44
Type of extremes	**max**	**min**	**max**	**min**
Periods	O_I,	1_I,	2_I	3_I
Boundaries, ka.	0-6.86	6.86-22.08	22.08-39.5	39.5-53.8
Events in the Pleistocene	Holocene optimum	Sartan glaciation	Karghinsky interglacial	Ermakovsky glaciation

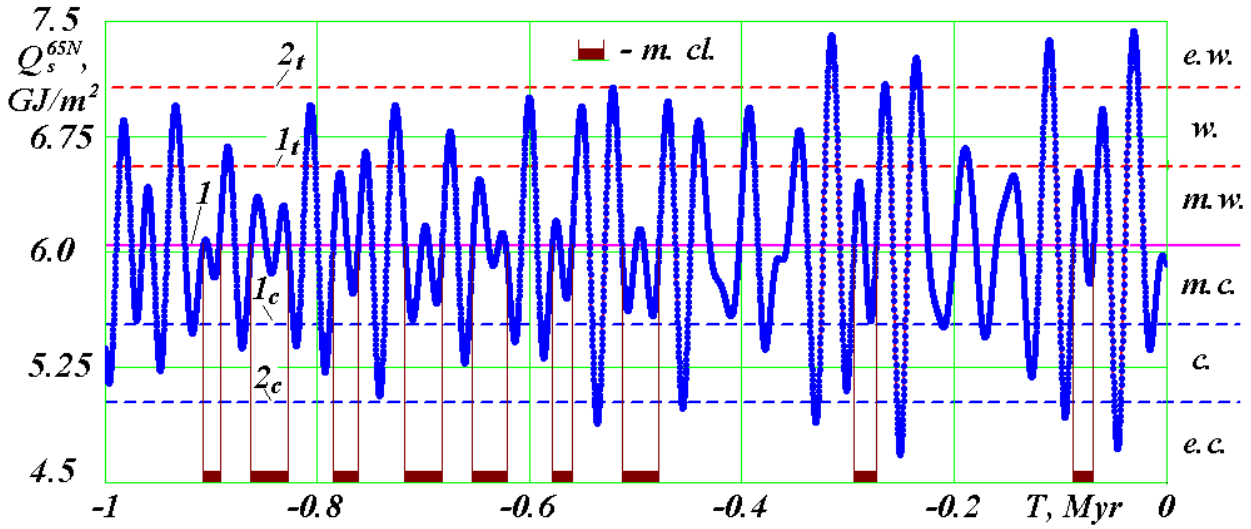

Fig. 6 Climate levels over a time interval of 1 million years: *1* – mean insolation Q_{sm}; *1t* and *2t* – the first or second boundaries of warm levels; *1c* and *2c* – the first and second boundaries of cold levels; m.w., w., e.w – moderately warm, warm, and extremely warm levels; m.c., c., e.c. – moderately cold, cold, and extremely cold levels.

The total number of cold (c.) and warm (w.) periods was 16 periods each. Other periods were moderately cold (m. c.) ones and moderately warm (m. w.) ones. Besides, there were nine moderate-climate (m. cl.) periods, which included both cooling and warming phases.

7. Moments of the Onset and End of Polar Days and Nights

In Fig. 7, the moments of the onset and end of polar days and nights are shown in the form of graphs plotted for various epochs [17, 23-24]. The graphs show the change in the day number T_d over the latitudes φ in Northern Hemisphere. The day number T_d is counted from the moment of vernal equinox, so that the number T_d = 0 corresponds to the moment of the equinox. It should be noted that 79 days pass from the beginning of the year to the moment T_d = 0. In region *I*, up to approximately T_d = 90 days, the onset times of polar days are given versus the latitude φ. Different lines and points show graphs for five epochs. Similarly, in region *II*, at approximately 90 < T_d < 180 days, the same lines indicate the moments T_d of the end of polar days. In the same way, at approximately 180 < T_d < 270 and T_d > 270 days, respectively the onsets (*III*) and ends (*IV*) of the polar nights are shown.

For example, in the contemporary epoch, T = 0, at latitude φ = 70°, following T_d = 56.88 days after the moment of vernal equinox, a polar day sets in. This day ends at T_d = 128.82 day. The polar night begins at T_d = 250.05 day and ends at T_d = 302.39 day. With increasing latitude φ, both polar days and nights begin earlier, and end, begin later. With decreasing latitude φ, the beginning of polar days moves away and

approaches T_d = 92.8 days, and the beginning of polar nights approaches T_d = 275.5 days. This occurs at latitudes close to the latitude of the Arctic Circle, which in the present epoch is 66.56°.

In other epochs, as it is evident from Fig. 7, the graphs of the beginning and end of polar days and nights are identical, but the latitude of their onset can shift substantially. As a result, the duration of polar days and nights varies in length. For example, in the epoch of 31 ka, the latitude of the onset of polar days and nights shifts respectively to 56° and 58°, and in the epoch of 46.44 ka, to 74° and 76°.

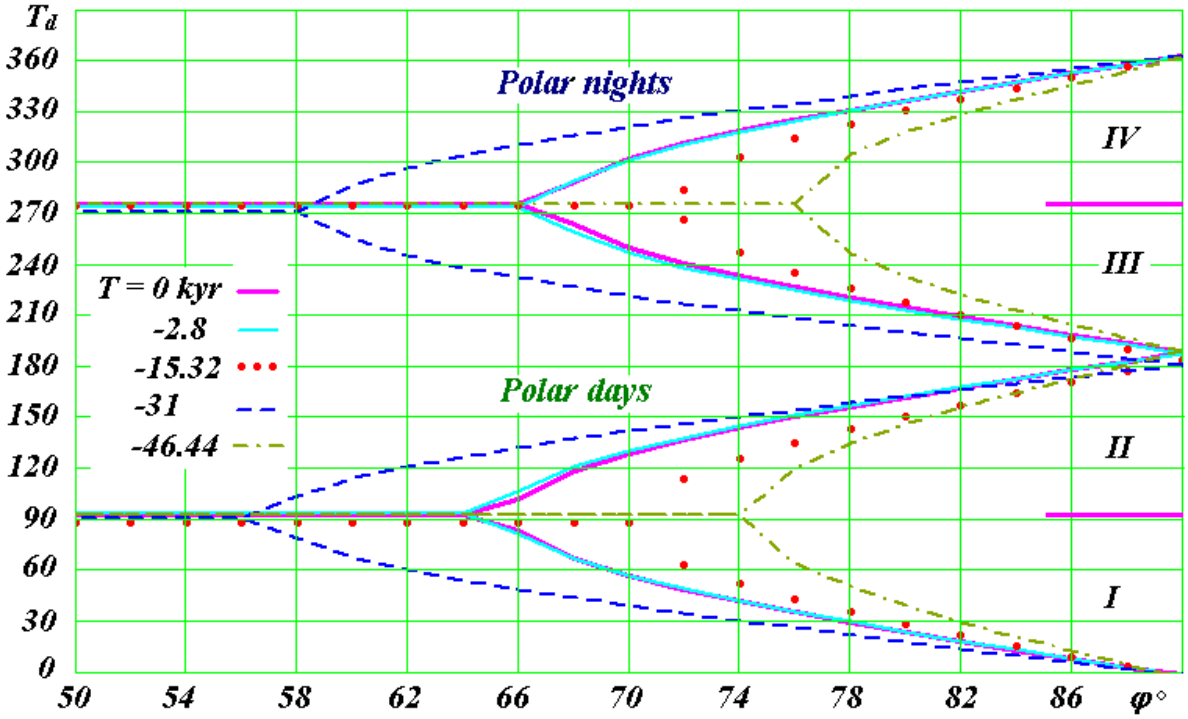

Fig. 7 The times T_d of the onset *I* and end *II* of polar days, and the onset *III* and end *IV* of polar nights at various latitudes in Northern Hemisphere during the extreme epochs over the last 50 thousand years.

It should be noted here that B.G. Tilak [25] studied the texts of the Vedas, Bhagavad-Gita, Avesta and other ancient sources. These texts cite the characteristics of the polar zone, as if the ancient Aryans lived in it. This can only be explained by large angles ε. In this case, the Arctic Circle passes to the south of its present location and, in addition, it becomes warmer at these latitudes. This creates necessary conditions for human life in the polar zone. This could happen in the epoch of -31 kyr. Ancient Aryans could inhabit a territory close in latitude to Tyumen (φ = 57.15°) and observe polar days and nights. With the approach of the last ice age, with a minimum of insolation having occurred 15.88 thousand years ago, Aryans were forced to migrate to southern territories.

The beginnings of polar days T_{dd} and nights T_{dn} and their durations $\Delta T_{dd} = T_{dd1} - T_{dd}$ and $\Delta T_{dn} = T_{dn1} - T_{dn}$, respectively, where T_{dd1} and T_{dn1} are the days of their end, are given in the tables published in [23-24]. These data are given for five different epochs at different latitudes in Northern Hemisphere. The change in latitude φ is given at 2° steps starting from the pole. The latitudes change to values after which no polar day occurs.

The theory and program SunPhnmen.mcd for calculating the total length of daylight hours, the duration of polar days and nights, and other solar phenomena is given in [17, 23-24]. This program and files with data on the evolution of Earth's orbital parameters and rotational motion are freely available at

the site http://www.ikz.ru/~smulski//Data/Insol/. Using them, one can determine the solar phenomena for any epoch over a time interval up to 20 million years ago.

8. Conclusions

1) Ice Ages occur at latitudes greater than 50°. At this time in the equatorial latitudes it becomes warmer.
2) Summer in the Ice Ages is colder than the contemporary one and the stronger than the greater a geographic latitude.
3) Winter during the Ice Ages is warmer than today throughout the globe.
4) In warm epochs, polar days and nights come to the south of contemporary places, for example, near the city of Tyumen, and during glacial periods – to the north, for example, north of Bely Island.
5) Ice Ages may recur after 30 thousand years, and may not occur even after three hundred thousand years, i.e. there is no their periodicity.
6) Insolation periods of climate change are defined. They coincide with paleoclimate changes. Therefore, the insolation periods are a reliable means for solving paleoclimate riddles.

Acknowledgments

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The results are based on the solution of the problems about the orbital and rotational motions obtained on supercomputers of the share use center at the Siberian Supercomputer Center, Institute of Computational Mathematics and Mathematical Geophysics SB RAS, Novosibirsk, Russia.

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Development of Value-added Lucent: Transparent Glass Using Hazardous MSWI Fly Ash

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Abstract: Municipal solid waste incineration (MSWI) fly ash (FA) containing hazardous metals (especially Pb and/or Cd), high water-soluble chloride (Cl^-), and other complex constituents bring on a traditional treatment of solidification/stabilization (S/S) and landfill disposal in most countries. In this paper, a MSWI FA sampled from M Plant was studied for developing an innovative method of fabricating value-added lucent/transparent glass. The analysis of MSWI FA shows that TCLP-Pb was 36.0 mg/L exceeding regulatory limit (5.0 mg/L) and Cl^- content was 32.84%. Composition analysis of MSWI FA illustrates that total chloride (Cl_T) of 35.39% was the largerest constituent and Cl^-, occupying nearly 93%, is the majority of Cl_T. Other abundant constituents were Ca (25.17%), Na (7.07%), K (5.01%) and Pb (2.68%) etc., revealing the possibility of fabricating glass. Unfortunately, Fe content in FA was 0.6%, larger than 0.1%, which may display green color in glass. Pre-experiments of fabricating glass using MSWI FA, silica sand (SiO_2) and flux (Na_2CO_3) concluded that 30%: 40%: 30% and 1,300°C firing temperature was the optimal fabrication condition but a green glass was also generated. Further efforts including pre-treating FA by magnetic removal of iron constituents and adding decolorizer (CaF_2) were explored. Finally, a lucent/transparent glass fabricated by the combination of pre-treatment of FA and adding 10% of CaF_2 was obtained. Further application of this simple and quick method, replacing the traditional S/S and landfill disposal, to fabricate value-added glass and achieve circular economy is highly expected.

Key words: municipal solid waste, incineration, fly ash, glass, circular economy

1. Introduction

Municipal solid waste incineration (MSWI) has been widely applied in developed and some developing countries because it can considerably reduce waste volume and recover thermal energy to generate electricity. However, MSWI residue, about 18–20wt% of MSW, will be generated [1]. Normally, MSWI residue includes 80wt% of bottom ash (BA) and 20wt% of fly ash (FA). BA is usually identified as non-hazardous waste since it can pass the regulations of toxicity characteristic leaching procedure (TCLP) and dioxins (DXN), and the screened BA can usually be recycled as a low-level of aggregate material. Unfortunately, MSWI FA is typically identified as a hazardous waste because of failing TCLP, especially in Pb and/or Cd [1, 2]. Moreover, MSWI FA can pass DXN regulation unless those fly ashes generated under abnormal conditions (e.g., wastes containing high organic chloride and aromatic precursor compounds, and low combustion temperature).

Besides TCLP and DXN for MSWI FA, people intensely notice the water-soluble chloride (Cl^-) content in MSWI FA even Cl^- content is not included in the regulation of hazardous waste [2]. The most reason of concern is Cl^- has corrosive characteristics that will damage iron or steel containing constructions and reduce structure strength gradually. Thus, cement solidification/stabilization (S/S), a convenient but defective method for treating hazardous MSWI FA, is

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usually applied in most of countries (including Taiwan, Mainland China, and most of European countries). The S/S of MSWI FA will increase 50% weight and the solidified FA will be transported and finally dumped in isolated landfill sites. This S/S and landfill disposal method not only occupies much landfill space but also has the risk of leaching out hazardous matters (e.g., heavy metals and DXN) and contaminating the soil and water environment. Conclusively, developing an innovative method for replacing S/S and landfill disposal and benefitting MSWI FA recycle is definitely urgent and important.

Glasses can be classified according to its shape and function as flat glass, container glass, car glass, and tube glass etc., and flat glass and container glass are the majority [3]. Most of the flat glass and container glass are SiO_2-based silicate glass. In addition, SiO_2-based silicate glass can be further divided into four categories according to its color: transparent (or colorless), brown, green, and variegated. Transparent glass can be recycled as transparent glass and added into other color glasses. Therefore, transparent glass has the highest value among all color glasses. In this paper, a transforming MSWI FA into value-added lucent/transparent glass method is presented. Iron compound, lager than 0.1% in the raw material of glass, will cause green color [3, 4]. Unfortunately, the iron compound in MSWI FA is normally lager than 0.1%. So several efforts in this paper to reduce the iron effect will also be studied.

2. Material and Methods

2.1 Sampling and Property Analysis of MSWI FA

MSWI FA generated in a MSWI plant (M Plant) located at central of Taiwan, ROC, was sampled and taken to laboratory. After drying and mixing, MSWI FA was stored in a close box for use. The physico-chemical properties of MSWI FA were measured in accordance with the standard methods of Environmental Protection Administration (EPA) of ROC and Chinese National Standard (CNS), including pH value (NIEA R208.04C, EPA), TCLP (NIEA R201.15C, EPA), water-soluble chloride content (refer to CNS 13407), metal concentrations (atomic absorption spectrometer), and composition analyses (SEM/EDS and FPXRF).

2.2 Glass Fabrication Experiments Using MSWI FA

Pre-experiments for finding out the optimal ratio of MSWI FA: silica sand (SiO_2): flux (K_2CO_3) and optimal firing temperature to fabricate glass were carried out firstly. Next, MSWI FA was pre-treated by magnetic removal for reducing iron compound and then fabricated according to the optimal condition of pre-experiments. Moreover, adding CaF_2 as a decolorizer was also explored and therefore the best glass with lucent/transparent characteristics would be attained after the comparison of all fabricated glasses.

2.3 Leaching Test of Fabricated Glass

A leaching test in accordance with the standard method of ISO 7086-1:2000 (release of Pb and Cd of glass hollowware in contact with food) was conducted for the best fabricated glass to ensure its safety and feasibility in future application.

3. Results and Discussion

3.1 Physico-Chemical Properties of MSWI FA

The pH of MSWI FA was 11.7 as shown in Table 1, indicating that MSWI FA is a highly alkaline waste because of FA containing many alkali metal oxides and alkaline earth metal oxides. TCLP-Pb concentration (36.0 mg/L) exceeding regulatory limit (5.0 mg/L) means that MSWI FA was a hazardous waste. Additionally, water-soluble chloride content was up to 32.84%, implying that a certain of organic chloride compounds containing wastes (e.g., PVC, rubber, and leather) were combusted.

3.2 Composition Analysis of MSWI FA

The composition analysis by SEM/EDS was shown in Table 2 and presented as follows: Cl (35.39%), Ca

(25.17%), O (19.13%), Na (7.07%), K (5.01%), Pb (2.68%), S (1.66%), Si (1.64%), Zn (1.14%), Al (0.59%), Mg (0.31%), and Cu (0.22%). The largest constituent was Cl (i.e., total chloride, Cl_T, including water-soluble chloride and water-insoluble chloride), 35.39%, and the water-soluble chloride was 32.84%; revealing that water-soluble chloride, occupying nearly 93%, is the majority of chloride in MSWI FA. The second largest constituent was Ca because of abundant Ca in waste and lime adding in air pollution control devices (APCDs).

3.3 Primary Metal Contents in MSWI FA

The analysis of primary metal contents in MSWI FA by FPXRF was shown in Table 3 and presented as follows: Zn (12,540 ppm), Fe (6,260 ppm), Pb (2,354 ppm), Cu (1,092 ppm), Cr (263 ppm), and Cd (188 ppm). Fe content of 6,260 ppm (i.e., 0.626%), larger than 0.1%, indicates a green color glass might be fabricated.

Table 1 The physico-chemical properties of MSWI FA.

	pH	TCLP (mg/L)					Cl^- (%)
		Cd	Cr	Cu	Pb	Zn	
MSWI FA	11.7	ND	ND	0.17	36.0	2.7	32.84
Regulatory limit	2.0 < pH < 12.5	< 1.0	< 5.0	< 15.0	< 5.0	< 25.0*	N/A

* Regulatory limit before 2001.

Table 2 The composition of MSWI FA.

Element	Weight (%)					
	Sample 1	Sample 2	Sample 3	Min.	Max.	Avg.
O	19.08	18.91	19.39	18.91	19.39	19.13
Na	7.13	7.17	6.92	6.92	7.17	7.07
Mg	ND	0.47	0.45	ND	0.47	0.31
Al	0.58	0.36	0.84	0.36	0.84	0.59
Si	1.69	1.57	1.65	1.57	1.69	1.64
S	1.63	1.65	1.71	1.63	1.71	1.66
Cl	35.18	35.78	35.2	35.18	35.78	35.39
K	4.74	5.04	5.26	4.74	5.26	5.01
Ca	25.08	25.73	24.7	24.7	25.73	25.17
Cu	0.65	ND	ND	ND	0.65	0.22
Zn	1.51	0.34	1.56	0.34	1.56	1.14
Pb	2.74	2.98	2.32	2.32	2.98	2.68
Total	100	100	100	100	100	100

Table 3 Primary metal contents in MSWI FA.

	Sample 1	Sample 2	Sample 3	Min.	Max.	Avg.
Cd (ppm)	186	186	191	186	191	188
Cr (ppm)	267	248	274	248	274	263
Cu (ppm)	1,103	1,114	1,058	1,058	1,114	1,092
Fe (ppm)	6,880	5,930	5,970	5,930	6,880	6,260
Pb (ppm)	2,414	2,288	2,359	2,288	2,414	2,354
Zn (ppm)	12,750	12,450	12,420	12,420	12,750	12,540

3.4 Glass Fabrications Using MSWI FA

The fabricated glasses by using MSWI FA were shown in Fig. 1. Green glass shown in Fig. 1(a) was caused by Fe content (0.626%) in FA. Magnetic removal of iron resulted in a light green glass shown in Fig. 1(b) because magnet can only remove ferromagnetic irons (e.g., Fe^0 and Fe_3O_4) and most of FeO (tending to display green color in glass) and Fe_2O_3 (tending to display yellow-green color in glass) were still remained. A significant more light green, yellow-green, glass shown in Fig. 1(c) was decolored by CaF_2. Finally, the combination of magnetic removal and adding 10% CaF_2 could fabricate a lucent/transparent glass as shown in Fig. 1(d).

3.5 Leaching Test of Fabricated Glass

Leaching test result of the best fabricated glass was shown in Table 4. The concentrations of Cd and Pb were ND, indicates that no any hazardous Cd and Pb will release during the glass contacting with food; therefore, the safety of glass made from hazardous MSWI FA was ensured. However, future application for non-food contacting glasses usages is suggested.

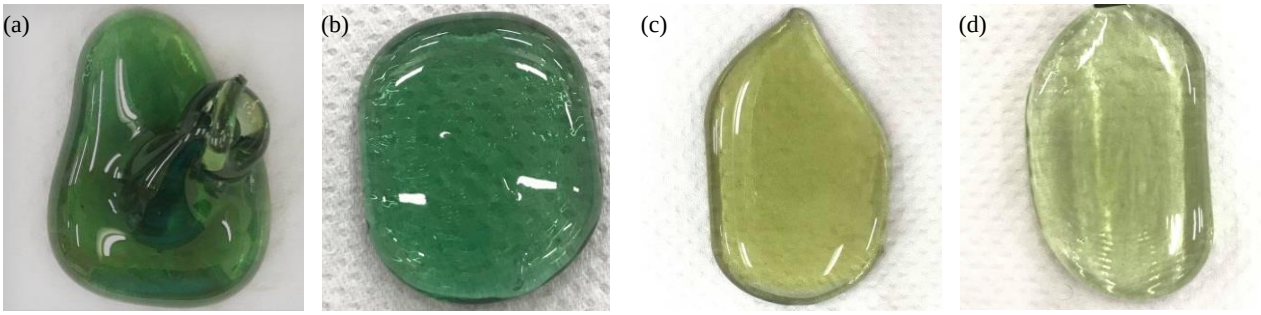

Fig. 1 Glasses fabricated by using MSWI FA in FA : silica sand (SiO_2) : flux (K_2CO_3) = 30% : 40% : 30% and 1,300°C of firing temperature. (a): original FA, (b): magnet pretreated FA, (c) original FA + 10% CaF_2, and (d): magnet pretreated FA + 10% CaF_2.

Table 4 Leaching test result of the best fabricated glass.

	Concentration	Regulatory limit*
Cd (mg/dm^2)	ND	< 0.07
Pb (mg/dm^2)	ND	< 0.8

* According to ISO 7086-2: 2000

4. Conclusion

MSWI FA as a hazardous waste was traditionally treated by S/S and landfill disposal. An innovative method for recycling MSWI FA and successfully fabricating value-added lucent/transparent glass was developed and presented. Replacing the traditional treatment of MSWI FA is highly expected in the future. Although the result of leaching test conducted in accordance with ISO 7086-1:2000 presented as ND for Cd and Pb, all the glasses fabricated by using MSWI FA are recommended for non-food contacting usages for avoiding any argument.

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Experience Report: Ecotourism as an Instrument for the Preservation of Historical-Cultural and Environmental Heritage

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Abstract: This experience report is the result of the extension project "Ecotourism at Brasital", whose purpose is the dissemination and preservation of the cultural and historical heritage of the Educational, Cultural and Tourist Center (CECT) Brasital, an old textile factory inaugurated in 1890 in São Roque, a town located in the state of São Paulo, Brazil. Fieldwork and action research were used — those involved the study of local history and oral stories, the manufacturing of signs with identification of trees and description of historical buildings, waste collecting, historical-cultural monitoring and environmental education in ecological trails. Besides that, small interventions were carried out in the place and, as a consequence, there was an increase in the number of visitors during the period and the diffusion of principles of maintenance and cleaning of public space.

Key words: ecotourism, historical and cultural heritage, environmental education

1. Introduction

São Roque, is a town with approximately ninety thousand inhabitants (Brazilian Institute of Geography and Statistics, IBGE), is located in the state of São Paulo, just 60 km from the capital, at a strategic place between two busy highways: Raposo Tavares (SP 270) and Castello Branco (SP 280). Besides its strategic location, the town stands out for offering good life quality.

São Roque, among other cities in the state of São Paulo, is considered a tourist destination since it attracts visitors because of the Wine Route (a 10 kilometers road with more than 30 business establishments among wineries, wine houses and restaurants) and Ski Mountain Park — an amusement park which offers skiing, ice skating, snowboarding, tree climbing, paintball, archery, tracking, horse riding, climbing, cable car and playground [1]. The town is also part of two tourist circuits: "Taipa de Pilão Circuit", which is located in the state of São Paulo and was created using historical assets listed by IPHAN (Institute of Historical and Natural Artistic Heritage) and "Itupararanga Tourist Circuit", which is formed by the cities located in the area under influence of the APA (Environmental Protection Area) of the Itupararanga dam [2].

São Roque still has 40% of its territory covered by Atlantic Forest vegetation and is one of the 73 cities included in the "Biosphere Reserve of the Green Belt of the São Paulo City" (RBCV), which differs from other biosphere reserves by making its priority the preservation of a significant vegetal heritage of original cover of Atlantic Forest biome [3].

Today, museums and historic buildings throughout Brazil - including São Roque — suffer from the neglect of public administration, besides that, there is a lack of

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understanding of the population about the cultural and historical function that these buildings represent. Damage caused by fires such as the ones that affected The Portuguese Language Museum in São Paulo, in 2015, and National Museum of Rio de Janeiro, in 2018, which had most of its asset burned, are unrecoverable losses for culture and science.

Located in the center of São Roque, the old Brasital S/A factory is considered a historical heritage in the town. It was built in the late 19th century and it was an important textile factory that produced cotton-based textiles and employed 80% of the available labor in the town by that time. However, after several difficulties related to the invention of new technologies, the factory was closed in the 1970's [5].

After almost 20 years of complete abandonment of its buildings by the old owners, in 1987, the mayor of São Roque, Mr. Mário Luiz Campos de Oliveira obtained the right to use part of the buildings and turned the space into an educational center for the city and region. Nowadays, the space is known as the Educational, Cultural and Tourist Center (CECT) Brasital and it is used by some departments of the City Hall for cultural and educational purposes, such as artistic and professional workshops. Besides that, the municipal library (Professor Arthur Riedel) and the Department of Education and Culture are located at CECT Brasital. There is also an extensive forest area around the old factory [6].

Although it is a space with several cultural and educational attractions, and therefore visited by hundreds of people every week, who come either to study in cultural and/or vocational courses or to have family leisure (picnic and/or photo album), it is possible to notice, from exploratory research [7], a certain disregard from many regular visitors and tourists related to the maintenance of the place and to the preservation of the forest. Thus, the extension project "Ecotourism in Brasital: an experience of historical, cultural and environmental tourism in São Roque" (which is in accordance with São Paulo Federal Institute (IFSP), from 2015, 2016 and 2017, and has the official right to select monitors and volunteers), promoted by São Roque Campus (IFSP/SRQ), in partnership with the City Hall had, since its beginning the following purposes: 1) to work on the physical conservation of CECT Brasital and its memoirs; 2) to contribute to the preservation of its forest and ecological trails; and 3) to promote social and environmental awareness of visitors and tourists. In order to achieve these results, historical-cultural guiding tours monitored by students were carried out. During those tours some "oral stories" about the factory were reproduced by the guides/students and, about everything, Environmental Education (EE, hereinafter) was practiced in ecological trails. As part of this monitoring practice, students had to survey and register species of flora, as well as making wooden signs showing the trees identification and historical facts of each building of CECT Brasital [8].

In the reflections and orientations on the practice of Ecotourism activities, different researchers point out that these should be associated with EE in parks, museums, schools, environmental preservation areas, etc., specially through environmental awareness programs. Self-guided trails or trails with specialized guides, museums with EE classes with taxidermized animals, demonstration of the interaction between fauna and flora of the region and projects of meliponaria with stingless bees are some examples of ecotourism practices. These activities should also integrate the local inhabitants to help with preservation actions of the area, while also reflecting on the impacts of anthropic actions that degrade the local environment [9].

From these and other orientations, the project "Ecotourism in Brasital" developed a rich experience which is reported in this text.

2. Material and Methods

With the objective of producing information and knowledge of more effective use, the project

"Ecotourism in Brasital" used field work and action research as methodologies. Thus, it aimed to promote conditions for actions and to transform either the place as the environmental conception of its visitors.

3. Results and Discussion

In 2015, when the project began, a historical survey of the buildings belonging to the old factory and its founder was carried out. At that time, the fauna and flora of the ecological trails began to be cataloged, specially from the trail named "Path of the Waters", which lengths about 2,500 meters. For the construction of the historical-cultural and environmental itinerary presented during the monitored tours, it was made a bibliographical review about the history of São Roque and Brasital S/A and about notions of EE [10]. Information was also gathered from informal conversations with those responsible for the administration of the place. According to Article 1 of Law No. 9,795 of April 1999 from Brazil, which deals with EE,

> Environmental education is understood as the processes through which the individual and the community construct social values, knowledge, skills and attitudes aimed at the conservation of the environment, which is an asset of common use belonging to the people, essential to the healthy quality of life and sustainability. [11]

Many information used during the monitored tours on EE orientation were gathered by the students and volunteers during the classes at the Federal Institute of São Paulo, São Roque campus [12], especially from their classes in the undergraduate courses of Biological Sciences and Technology in Environmental Management.

The following year, 2016, historical information and orientation on EE previously reviewed were the basis to elaborate a presentation script for the monitored visits that would happen in buildings of the former Brasital S/A and in some of the ecological trails. The definition of the routes for the trails and the small lectures given at each point of stop were based on the data previously reviewed by the students and volunteers of the project.

Simultaneously to the elaboration of the monitoring script for the tours, a logo and a mascot for the project "Ecoturism at Brasital" were also created. The architecture of the buildings inspired the development of the logo, which used the lines and the orange color of the roof and the tower as a representation of the factory's rich culture and history (also emphasized during the monitored visits) — and the green of the two trees representing EE and the ecological trails (see the images below). The project's mascot, designed to draw children's attention to the importance of the preservation of the place, was created in honor of the founder of Brasital S/A, Mr. Enrico Dell'Acqua. By a vote among the members of the extension action, which was also open to public participation in the Facebook, it was chosen the name "Enriquinho" for the mascot. T-shirts were manufactured to make the identification of monitors and volunteers easier. From a new vote among the team, a model was defined; the logo of the project was used, as well as the logo of the IFSP/SRQ, the words "Environmental Monitoring" were printed on the front part of the T-shirt. A survey of some tree species found in the ecological trails around the factory was also carried out [13]. Thus, species of different types and forms are chosen according to their origin: some are native species (belonging to the local ecosystem, in this case, Atlantic Forest), there are also exotic species (that are outside their natural environment) and there are exotic-invasive species (species outside their natural setting that cause negative ecological impacts) [14].

After having classified the trees according to the previous definition and identified the selected ones, each tree was marked with a simple label containing its popular name. The next step was to research data such as the scientific name, their families, origins and some curiosities about them, which was done with the help of IFSP/SRQ teachers. Therefore, with all the information collected and properly organized, identification signs

of these trees were made (Fig. 1) to ensure that all the visitors — even if they were not participants of the monitored visit — knew the names of the trees and some of its specifications. The material used to install the signs was received because of a partnership with a woodworking course that takes place at CECT Brasital. The signs also have QR Code technology, which allows visitors to access other information about the trees.

The signs were made and printed on common paper, after that they received a plastic coating to withstand rainfall and some other eventualities. Finally, they were attached to wooden structures and installed in front of each tree (Fig. 2).

To stimulate greater interaction between the space and the project "Ecotourism in Brasital", the visitor, when approaching the reader of his/her cell phone to the existing QR Code installed on trees, was sent to a link that presented a card with the description and curiosities of each tree (Fig. 3). In total, 30 identification signs of the trees were made and installed throughout the area which was part of the trails covered during the monitored visits.

In 2016, before the time set for the monitored visits on Sundays, solid waste was collected in the pre-established route for the trails (that was a suggestion of the students/monitors and volunteers of the project). In fact, this habit of collecting waste in the forest became a mark of the team, encouraging other

Fig. 1 QR code technology.

Fig. 2 Installation of signs on trees in CECT Brasital.

Fig. 3 Example of card with the description of the trees.

visitors to collect their waste, or at least not throw things on the ground.

In 2017, after a positive response from the visitors and the local press [15], the project team made signs describing the historic buildings and areas of greatest relevance for the operation of the old factory (Fig. 4). In order to help visitors, signs for public toilets were also installed.

The historical signs were installed in areas of greater importance for the former Brasital S/A, as the warehouses; the chimney; the steam whistle; the Carrara marble fountain; and the sculpture in the shapeof a centipede, which has become a symbol of the Cultural Center Brasital. Thus, 8 signs with the identification of historic buildings and the QR Code technology (the code is linked to Facebook page of the project, which included photos of all monitored visits, old pictures of the town and of Brasital S/A with its

Fig. 4 Sign with the description of historic buidings at CECT Brasital.

machinery and plant construction from the 19th century).

In September, 2017, the project also carried out a public event destined to collect solid waste in the trails and gardens of CECT Brasital and to raise environmental awareness, that attracted dozens of people. Monitored visits occurred during 2016 and 2017, between April and November, on Sundays, from 10:00 a.m. to 3:00 p.m. During the visits students and volunteers walked along the buildings and told the stories from oral tradition about the time when there were workers in the old factory, they also included facts from the history of the city. After that, the visit went on the ecological trail, where EE took place, monitors addressed issues such as sustainability, the importance of trees, litter decomposition and other issues related to the forest of CECT Brasital.

3.1 Advances and Setbacks in Historical-Cultural and Environmental Preservation Actions

During the three years of the extension project "Ecotourism in Brasital: an experience of historical, cultural and environmental tourism in São Roque", there was a significant increase in the number of visitors, mainly on Sundays, when monitoring took place. The project managed to disseminate notions of Environmental Education to 40 visitors on average over the weekends.

Over time, it was evident that visitors kept the place cleaner, it is believed that this was somehow related the action of the EE project and some other activities, such as the collective cleaning event and the collection of waste by the team, the latter being done weekly before the monitored visits.

Even with a noticeable decrease in the amount of waste left on the trails, it was necessary to carry out a profile research of visitors, that was because part of them still threw waste around. The study of Pugas e Silva (2017) revealed that the largest public of CECT Brasital were residents of the city of São Roque (62%), and the main reason for the visits was to study, either for courses offered in the place or to use the library. Among other activities, many people go to the place to have lunch and quick snacks. Besides the historical-cultural and environmental monitoring, 22 tree species from 16 different families were identified in the survey done by the members of the project, as well as 30 signs were manufactured, which means that, many species were cataloged in a small area — the total area of forest contains approximately 30,000 m^2, rich in diversity of species, many native, exotic and exotic-invasive. Regarding the species of trees identified only in the area that is part of the environmental monitoring trails, 22 tree species from 16 different families were cataloged, 3 Cupressaceae, 2 Arecaceae, 2 Moraceae, 2 Fabaceae, 2 Malvaceae, 1 Salpindaceae, 1 Euphorbiaceae, 1 Myrtaceae, 1 Rosaceae, 1 Salicaceae, 1 Lauraceae, 1 Rutaceae, 1 Bignoniaceae, 1 Anacardiaceae, 1 Meliaceae and 1 Protoceae. Thirty identification signs were made for the trees (some of them were duplicated).

By the end of 2016, the year when the signs for the trees had been installed, it was noticed that only one of the 30 boards that had been installed was removed, therefore, 29 remained intact since its installation — some repairs had to be performed during this period, such as the cleaning of the material due to graffiti, some pieces of broken wood that were replaced with new ones and there were still small infiltrations by

rainwater. In the end of 2017, considering the 8 historic signs that had been installed, only the sign attached to the centipede sculpture was damaged and had no repair and another sign needed small repairs. Therefore, although some graffiti were seen both on the identification signs of the trees and in the signs of the historical buildings, none suffered irreversible damages due to vandalism.

In general, publications in the town's main newspapers helped to promote the project, an example was a SPTV report about São Roque (2016), which presented the town as an important tourist destination, mentioning The Wine Route and CECT Brasital, referring to the participation of IFSP/SRQ students in Environmental Education activities in that place.

In addition, important partnerships were established during this period, with COMTUR (Municipal Tourism Council) — which contributed to the dissemination of the project; with restaurants in the city — which helped with the supply of food to the students and project volunteers; and with the São Roque Tourism Division — that provided brochures to promote the city's tourist attractions.

All the activities developed in the project were presented at congresses of scientific initiation and extension as at the VI Congress of Scientific and Technological Initiation of the IFSP, held in Itapetininga Campus in 2015; at the III and V Congress of Extension and Art and Culture Exhibition of the IFSP, held in Sertãozinho in 2016 and in Barretos, in 2018; (VII, IX and X CIPATEC) of the IFSP, held in São Roque, in 2015, 2017 and 2018, and at the 8th Brazilian Congress of University Extension (8th CBEU), held at the Federal University of Rio Grande do Norte (UFRN), in Natal, Brazil.

4. Conclusion

We conclude that the preservation of places (parks) such as CECT Brasital depends on actions that involve the inhabitants in a sustainable way and at the same time, preserve the old buildings and value fauna and flora — principles that contribute to the awareness of visitors and tourists. This can be achieved through the practice of Ecotourism and consequent dissemination of the place as an important source of culture, history and leisure.

The attaching of identification signs to trees and historic buildings, as well as the public group events to collect solid waste help regular visitors and tourists to understand the need of prevention and conservation actions, raising awareness to keep the site clean and sustainable.

Although some of the signs were affected with the disregard of part of the visitors, as graffiti and small damages were seen on signs, in general, the installation activity has had a positive effect on public awareness. An evidence of this was the decrease in the amount of solid waste left in the woods after the installation of the signs and establishment of guided visits. Therefore, it was verified that the practice of Ecotourism could positively influence the preservation, education and environmental awareness in places with similar characteristics to those of the CECT Brasital park.

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Integrated Water Management Scheme — A Case Study of North Karanpura Super Thermal Power Project

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Abstract: North Karanpura Super Thermal Power Project (NKSTPP) with capacity of 3x660 MW is located in the Chatra District of Jharkhand, India. Water for North Karanpura STPP would require a sustained/continuous water supply from nearby available sources. Only available source in vicinity is river Garhi, which is rain fed and remains dry in non-monsoon periods. However, sufficient volume of Garhi river discharge, meeting the annual Plant demand of make-up water is available during the monsoon period. Initially, without Air Cooled Condensers (ACCs) total water required was about 55 MCM and to fulfill this huge water requirements of plant, dam of height 22.5 m and 1830 m length was envisaged. This required land acquisition to the tune of 5000 acres, including submergence of forest/fertile land and rehabilitation of some villages. To avoid the resettlement of villages and acquisition of forest/fertile land, an alternative scheme was worked out. In the present scheme, arrangement for lifting of water by pumping from river Garhi during monsoon period with storage facilities (raw water reservoir) in the plant area is envisaged. To reduce water requirement of power plant, power plant is now proposed with ACCs, thereby reducing water requirement to about 20 MCM. The present integrated scheme involves construction of a 6 m high and 121 m long barrage across river Garhi, with associated make up water pump house & pipeline of about 2.0 kms. length and raw water reservoir spread over 800 acres. The raw water reservoir inside the plant boundary has been designed to cater to the water requirements of non-monsoon period of nine months. During monsoon period of three months reservoir will store and also function as buffer & online supply to power plant. The low height barrage has been planned within the river regime and without acquiring any land. To avoid submergence of nearby Tandwa village and private fertile land on both sides of river even during flood peaks, the embankment as well as abutment wall of length of about 1.0 km. on both sides of banks has been provided. The Intake pump house has been provided at 100 m u/s of barrage for pumping the monsoon water from the river into raw water reservoir. The barrage control room building is planned to be constructed above the piers of the barrage. To avoid the seepage from the raw water reservoir 1 mm thick HDPE liner, geo-textile and 75 mm thick PCC at the bed and inside slopes of reservoir has been provided. The maximum height of reservoir embankment is 12.0 m and side slopes are 1V:2.5H. In this paper, integrated water management studies have been carried out for fulfilling the water requirement of North Karanpura STPP, thereby saving the resettlement of ten villages & about 220 nos. of families displaced and acquisition of about 5000 acres of fertile/forest land. This is a true example of sustainable development without using existing resources and using untapped monsoon flows.

Key words: North Karanpura, Garhi River, air cooled condensor, barrage, reservoir, guide bank

1. Introduction

For the development of backward areas of Chatra District of Jharkhand state, India, construction of North Karanpura Super Thermal Power Plant was conceived by Govt. of India way back in 1990. North Karanpura Super Thermal power Project (STPP) with installed capacity of 3x660 MW was primarily guided by ample availability of coal from Tandwa block of North Karanpura coal fields as pit head thermal power plant. NTPC Limited (A Govt. of India Enterprises) was entrusted for implementing the proposed power project. Water for North Karanpura STPP would require a sustained/continuous water supply from nearby available sources. The project is envisaged with Flue Gas Desulphurization (FGD) system and Air Cooled Condensers (ACC). The total project area is about 2200

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acres. The ash disposal area and raw water reservoir area are 500 acres and 800 acres respectively. Three numbers steel flue reinforced concrete chimney of 275 m height shall be provided, catering to the three 660 MW units of the project. Layout Plan for the project has been developed taking into consideration various aspects like available land & its shape, ground features & terrain, corridor for outgoing transmission lines, road approaches, prevailing wind direction, the water drawl and the associated pipe corridor. The layout of North Karanpura STPP is given below (Fig. 1) [3].

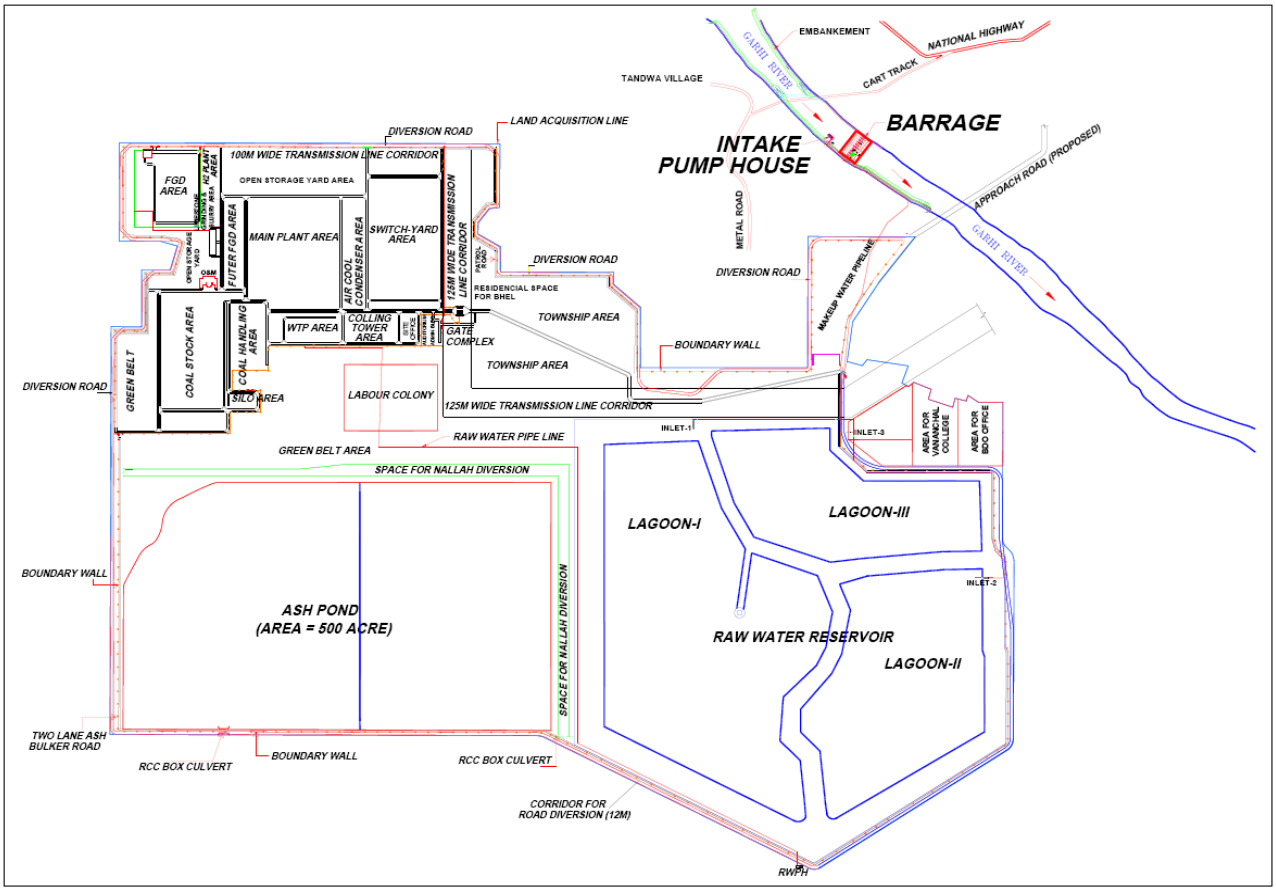

Fig. 1 Layout plan for North Karanpura super thermal power project.

2. Initial Proposal of Water Drawl Scheme

Initially, the power plant was planned to have closed cycle conventional condenser cooling and ash handling system with an estimated annual make up water requirement of about 55 MCM without ACC. The construction of 22.5 m Dam across Garhi river was envisaged to ensure a permanent source of water to meet the make-up water requirement throughout the operational period of the proposed thermal power plant. Garhi river is a tributary of Damodar river and is also known as Barki river in its upper reaches. The Damodar river and all its tributaries in the upper Damodar river valley are non perennial and the flows are confined mostly to the rainy season, i.e., June 15th to end of September each year. After September each year, the flows in these rivers dwindle down and all the rivers become dry for a considerable period of time during the post monsoon period [2].

The annual water requirement for the Power Plant was 80 MCM including evaporation & other requirement and it is considered that sufficient flows would be available for 4 months in a year in the Garhi River to meet this requirement and for the remaining 8 months, water is required to be stored in the dam submergence ~~reservoir~~. The main dam was envisaged

as a homogeneous type earth fill dam with a maximum height of about 22.5 m from the river bed level. The dam was designed with the central core filled with selected impervious material and the outer sides of semi-pervious or impervious material. A vertical chimney filter and a horizontal filter blanket along with a suitable toe drain arrangement was also proposed [2].

The length of the earth dam at the top level (El. 440 m) was 1650 m. The upstream slope is varying from 2.65:1 to 3.25:1 (H:V) and downstream slope is varying from 2.45:1 to 3:1. Provision of two nos. berms of five metre width and one no. berm of five metre width were proposed in U/S and downstream slope of the main dam respectively. The spillway structure would have a crest level of RL (+) 430.00 m above MSL and seven no. of bays of 12 m wide with 5.8 m high vertical lift gates. The Spillway was designed for the probable maximum flood (PMF) of 4417 cumecs. Pump house for supplying water to the makeup water system was proposed to pump 100 cusecs of water from the reservoir. The pump house was proposed to be located about 585 m inside the reservoir over the intake well to ensure all season water flow within the pump sump. The pump house with 4 nos. vertical turbine pumps of 50 cusecs capacity each, was designed as a multi-unit pumping plant with echelon setting of pumps.

For construction of 22.5 m high dam, land acquisition to the tune of 5000 acres, including submergence of fertile/forest land and rehabilitation of 10 villages was required and rehabilitation of about 220 families was required. The layout along with Dam & its submergence for earlier proposal is given below as Fig. 2.

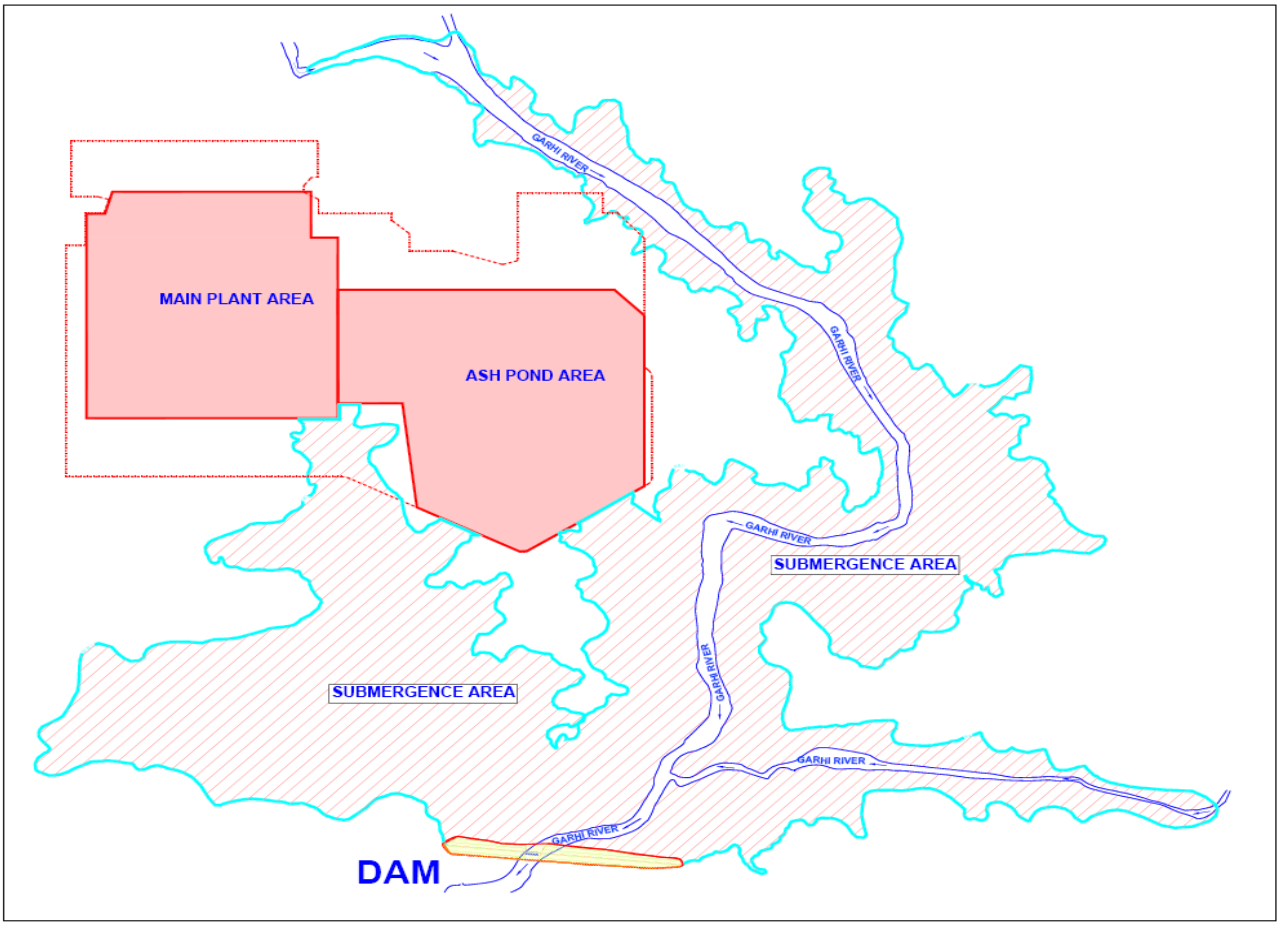

Fig. 2 Layout of Earlier scheme with Dam.

3. Revision of Water Requirement of Plant

Initially, plant was envisaged with conventional water cooled condenser for the power plant and make up water requirement was substantially high, i.e., 55 MCM. It was very difficult to acquire the land for the construction of dam and its submergence area. Therefore, condenser cooling system was reviewed for the proposed power project and revised with ACC, by which the annual requirement of water reduced to 20 MCM.

4. Result: Evolvement of Integrated Scheme

Even after reduction of annual water requirement for plant to 20 MCM, it was very difficult to acquire the fertile/forest land as well as rehabilitation of villages. Besides, it was also an environmentally un-friendly option to disturb fertile agricultural land, cutting of forest and the village habitats. To avoid the resettlement of villages and acquisition of forest/fertile land, an alternative scheme was worked out. Low height diversion structure (barrage) on the Garhi river along with storage (raw water reservoir) inside the plant boundary was studied and detailed scheme was worked out. The layout of barrage along with raw water reservoir & make up water pipe line is given in Fig. 3.

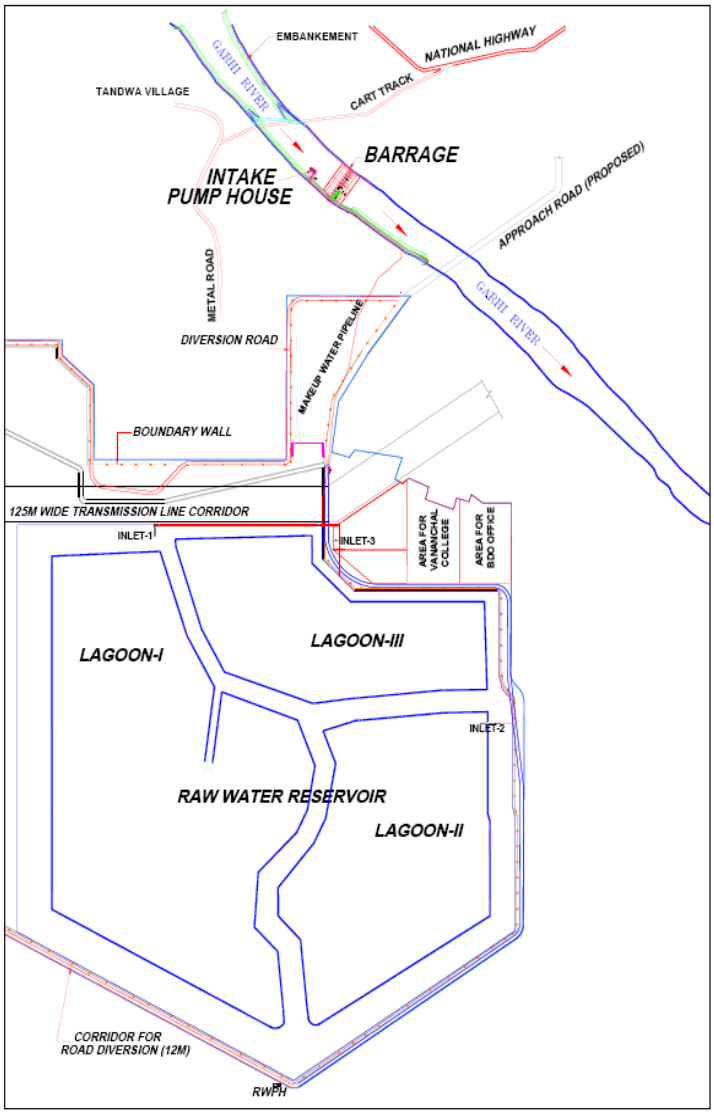

Fig. 3 Layout of water withdrawal integrated scheme.

The Cost comparison study between earlier proposal with Dam structure and integrated scheme has been carried out and given in Table 1.

The total cost of earlier Dam scheme was about INR 10,700 million, whereas for integrated sachem cost was about INR 5,200 million. Therefore, there is a saving of about INR 5,500 million with the implementation of integrated scheme instead of Dam scheme.

4.1 Water Availability Studies

For the proposed project site, the proximate Gauge and Discharge (G & D) site is at Ramgarh maintained by Central Water commission (CWC). The daily discharge data for Ramgarh available for the period 1986 to 2015, is in ten daily form. Based on the available flow data there is wide variation of flow in the river. The catchment areas of Ramgarh and proposed diversion site are 3434 Km^2 and 346 Km^2 respectively. The 10-daily flow series has been developed based on above data. The annual runoff for the 90%, 75% & 50% dependable year are 126 MCM, 182 MCM & 276 MCM respectively at proposed barrage site. The design flood of 1800 cumecs and 1550 cumecs for 1 in 100 and 50 year return period respectively have been developed. The sediment rate of 1 mm/year have been adopted for the present study [4].

Table 1 Approximate cost details of earlier proposal.

S. No.	Description	Rate (INR)	Total (in million INR)
1	Submergence of 3300 acres private land	1.5 Million/Acre	4950
2	Pension for 3300 acres private land owners	3300/Acre/month	350
3	Afforestation cost for 1700 acres forest land		1150
4	Dam cost		4250
TOTAL			INR 10,700 million
Cost details of the integrated scheme			
1	Barrage package cost		960
2	Reservoir package cost		4250
TOTAL			INR 5,200 million

4.2 Evolution of Barrage Structure

Study was for creating controlled condition of river flow by constructing gated barrage structure across river Garhi to regulate the river depth of flow, in accordance with the actual utilization flow depth requirement for pumping, as well as to facilitate river course sediment flushing. In the present case, the Garhi river is not perennial in nature, having braided river course with wide seasonal variation in river discharges. In present case, it is virtually without any considerable storage facility as the longitudinal river slope is limited to around 1 in 250 along with sediment laden flat river bed across. Garhi river is basically an alluvial river, where the river bed and banks are made of mobile sediment and/or soil. Thus suitable arrangement for flushing of deposited bed silt would be an essential requirement for the proposed diversion system.

The location of barrage has been finalized at d/s of Tandwa village on Garhi river considering the aspect of river morphology, proximity to plant area and mainly complete structure within the river regime and without acquiring any land. Due to flattening of river slope and river carrying certain amount silt during monsoon season, the bed of barrage is kept at river bed level at RL(+) 432.0 m to facilitate flushing of deposited silt at u/s of barrage. The FRL of barrage structure has been fixed as RL(+) 437.0 m using HEC-RAS software and 10 (ten) vertical gates are provided for controlling the river flow, as well as to facilitate passing of 1 in 50 year flood discharge. The top level of gates is kept at RL(+) 436.7 m corresponding to barrage sill level at RL(+) 432.0 m and ten number of bays of 9.5 m wide with 5.2 m high vertical lift gates with a rope drum hoist operating system. Basic purpose of the gate operation is to ensure requisite water level within the river to maintain submergence requirement of the pumping system. The barrage spillway bays will not be provided with stop log considering the purely seasonal status of Garhi river, which during the month of November to May in any year remains virtually dry and the public

cross the river course at ease. The plan and typical cross section & L-section of barrage are given in Figs. 4 & 5 respectively [6].

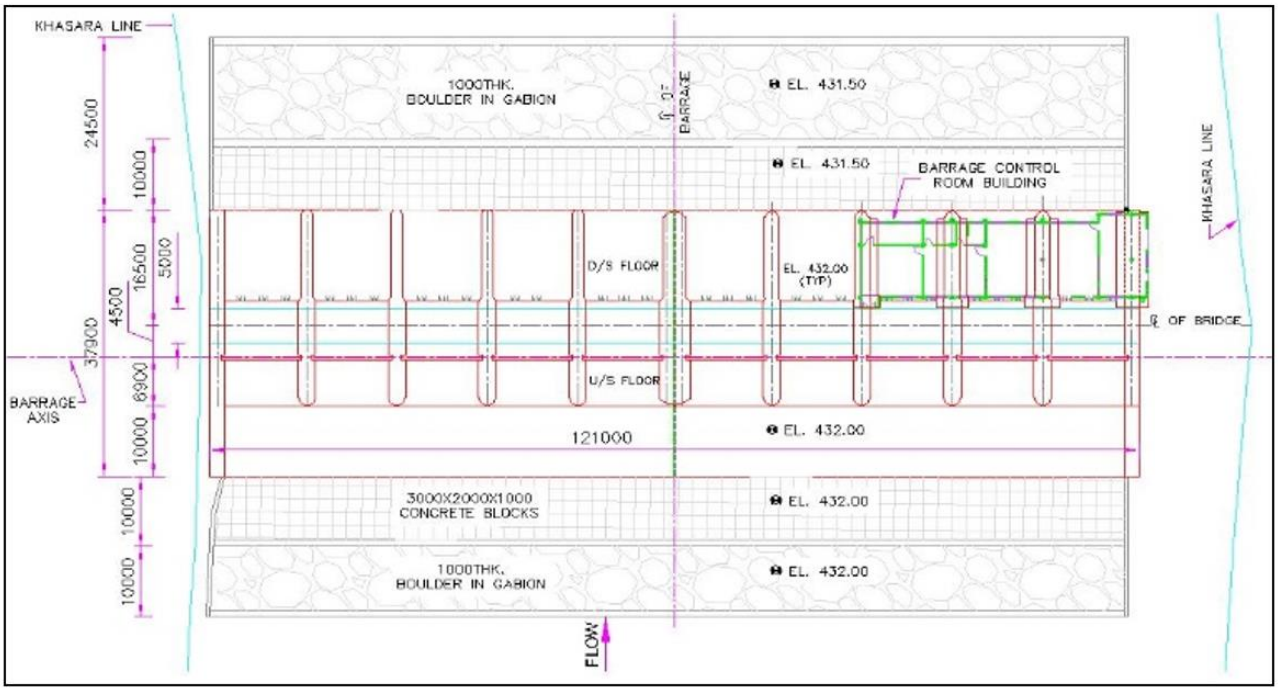

Fig. 4 Typical Plan of Barrage along with intake pump house.

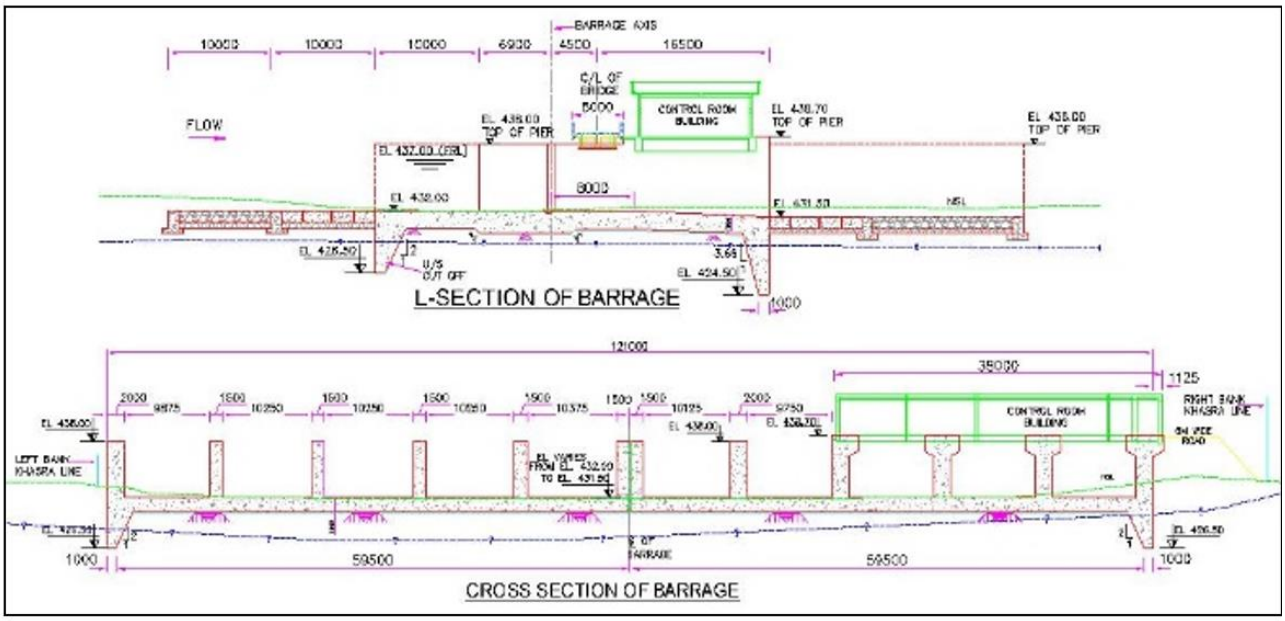

Fig. 5 Typical cross section and L-section of barrage.

4.3 Intake Pump House

The intake well structure is proposed at 100 m upstream of the proposed diversion structure on the right flanks of the river. It is necessary that the intake should be located for a minimum length of pipe lines so that the pumping efforts are economical for construction and during operation. Hence, a suitable location considering all the above aspects has been selected in the reservoir area. This location requires an

approach Bridge from the right bank to be built in the reservoir upto the Intake & structure which would be of 25 m length. The scheme shall comprise of six submersible pump sets installed in Pump house out of which five (5) pumps acting as main (working) and remaining 1 pump to act as standby. Rating of each pump shall be 3000 m^3/hr so as to pump the water available in the river to make up water reservoir in 60 days. Rated dynamic head of 40 m (approx.) is envisaged.

4.4 Evolution of Raw Water Reservoir

As the storage has not been envisaged at river end, it is necessary to store the water at the plant side. The raw water reservoir inside the plant boundary has been designed for storage of 18 MCM to cater the water requirements of non-monsoon period of nine months. During monsoon period of three months, reservoir will store and also function as buffer & online supply to power plant. The proposed Raw Water Reservoir, Raw Water Pump House and associated switchgear & control room facilities are located within the Plant's land acquisition boundary. The topography of the proposed Raw Water Reservoir area is undulating terrain with levels varying from RL(+) 434.0 to RL(+) 458.0. Total area available for the reservoir is 800 acres approximately. The maximum height of reservoir embankment is 12.0 m from reservoir bed and side slopes are 1V:2.5H. Construction of water escape structure is also envisaged. Construction of spillways is envisaged for discharging excess rainwater from storage area to the existing drainage. To avoid the seepage from the raw water reservoir 1 mm thick HDPE liner and 75 mm thick PCC at the bed and inside slopes of reservoir has been provided [4]. The sand chimney, sand blanket as well as rock toe, toe drain and stone rip-rap for downstream slope protection works of dyke embankment has been provided. Construction of peripheral bituminous inspection road on the top of the embankment of the reservoir is also envisaged. The water from the river Garhi is proposed to be pumped in the raw water reservoir by providing 1600 mm diameter pipeline. The Layout and Typical cross section details are presented in Figs. 6 and 7 respectively. The Sump pit has been provided to collect the rainwater within plant boundary and pump to the reservoir. This rainwater which going to the river and then to sea has been tapped and utilized for running of plant.

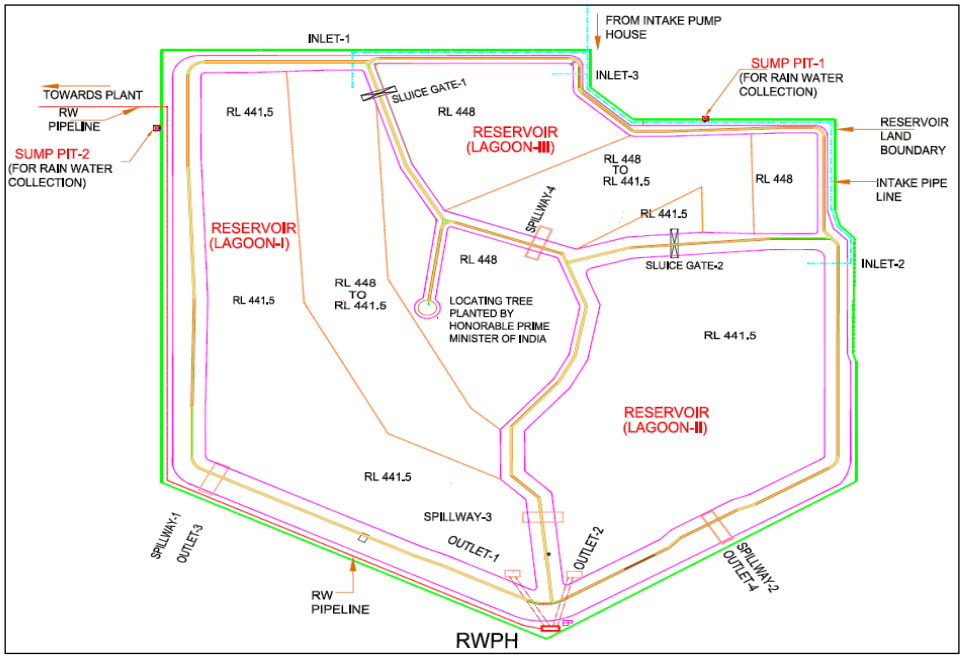

Fig. 6 Typical Layout of reservoir.

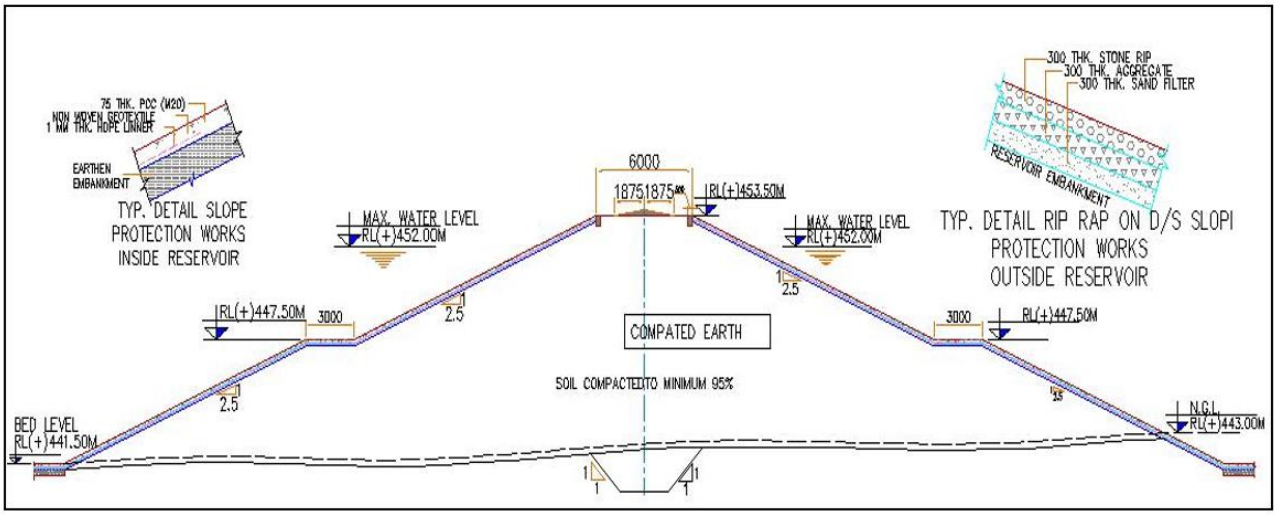

Fig. 7 Typical Cross section of reservoir embankment.

5. Conclusion

Initially, with conventional water based power plant cooling system, total water required was about 55 MCM. To fulfil this huge water requirement of power plant, dam of height 22.5 m & length of 1830 m was envisaged. This dam required land acquisition to the tune of 5000 acres, including submergence of fertile agricultural & forest land and rehabilitation of 10 villages comprising of about 220 families. As project authorities were unable to acquire this fertile/forest land and rehabilitate the villages for construction of dam on Garhi river, the project was getting delayed. It was also felt that such inundation of 5000 acres of fertile/forest land will disturb the ecological system of river, besides displacing the large nos. of villages. Therefore, to avoid the ecological disturbance of river, options were explored to reduce water requirement of power plant and to accommodate water facilities within the already acquired land for the power plant. Accordingly, integrated water management scheme, as detailed in the foregoing clauses was worked out, which included incorporation of Air Cooled Condensers (ACC), Low height Barrage within river regime and Raw Water Reservoir within the plant boundary. The new integrated water management scheme reduced water requirement to 20 MCM, thereby managing entire water scheme without any additional land acquisition and rehabilitation of villages.

In the present study, without tapping the water from the existing reservoirs/storages, without acquiring any additional land & rehabilitation of any villages and using only about part of 90% dependable yield of the river during monsoon, a dependable scheme for water requirement of power plant has been worked out. The total cost of earlier Dam scheme was about INR 10,700 million, whereas for integrated scheme cost is expected to be about INR 5,200 million. The present scheme in addition to being environmental friendly also resulted in cost savings. This is a true example of sustainable development and smart scheme without using existing resources and using untapped monsoon flows.

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Recent Approaches and Some Contributions in Family Fruit Growing in the Sierra Nevada de Puebla, Mexico

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Abstract: The fruit component that is part of the agricultural production system of the Sierra Nevada in Puebla contributes significantly to family income. The objective of this paper is to analyze the actions carried out, and the main results generated in research in the fruit sector, specifically in the last three approaches of this activity, which has been carried out since 1975. They focus on disciplinary research and technology transfer in native and creole fruit trees, through pruning, nutrition and pest control based on natural, biological and organic products, this has contributed to achieving better markets and the export of tejocote fruit, and have also been generated good results with conventional production and protection technologies in improved fruit trees such as peaches, apples and apricots. In a case study it was found that the levels of productivity and agricultural biodiversity were high (6 fruit species interspersed with 7 annual crops and 20 varieties in total). This indicated that multi crop farming systems are still profitable and important among small farmers; while native and creole fruit trees have recently gained importance as walnuts, apples, tejocote and capulín, both for fresh sale and in gastronomy. This has justified starting actions recently (2019) in a new regional fruit sustainable development project.

Key words: multiple cropping, native, creole and improved fruit trees

1. Introduction

In the Sierra Nevada of Puebla, family farming system is dominating, with small farmland, in which the fruit component, in terms of planted surface, follows corn (*Zea mays*), and exceeds beans (*Phaseolus vulgaris*) [1]. In 1975, as part of the operation strategy of Plan Puebla, research in fruit growing began to generate technological recommendations, as another form of contribution to family income, in addition to that coming from corn and beans, since these grains were addressed mainly for family consumption. This fruit component involved native species and introduced varieties of peach (*Prunus persica*), apple tree (*Malus domestica*), apricot (*Prunus armeniaca*), plum (*Prunus salicina*), pear tree (*Pyrus communis)*, walnut (*Juglans regia*), tejocote (*Crataegus mexicana*) and capulín (*Prunus serotina)*, among others of lesser economic importance and lower planted surface.

This method was used by two decades; however, in the early 1980s this type of fruit trees was studied with another approach [2], as part of the family production system (housing, backyard livestock, annual crops, forage and fruit trees in the home garden and in the farm plot) a project on development of an agricultural prototype was started.

Although, this was not enough to achieve remarkable advances in fruit production and income, by the late 1980s, research was reoriented towards the promotion of small family nurseries to propagate grafted plants with outstanding varieties, some genetically improved as in the case of peaches, from the Colegio de Postgraduados Campus Montecillo; this process was driven under the family microenterprises of Plan Puebla approach [3].

In the early 1990s, an improved peach cultivar was available and new orchards were planted with properly

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managed trees (interspersed with annual crops), this began in Chiautzingo, Puebla, where, later, an area of 100 hectares was planted [4], this remarks the initial impact achieved through the change of focus on the fruit component of the family agricultural production system. This experience contributed to the simultaneous establishment, at state level in Puebla, of farmers organizations that developed the cultivation of this species until reaching almost 3,000 ha in the late 2000s [5]. So the improved peach, and later the apple, apricot and other fruit species, have been studied in different ways: as part of the milpa system intercropped with fruit trees (MIAF) since the mid-90s [6], and since the mid 2000 to date, in simple orchards with a disciplinary research approach, evaluating cultivars, from which outstanding improved varieties have been selected and generated production technologies related to mineral and organic nutrition, managing and pruning tree systems.

A case study was carried out during the second half of the 2010s, to explore the degree of biodiversity that is occurring on site, and the levels of productivity obtained, both in fruit trees, as in annual crops that were intercropped between the rows of trees. For culinary and gastronomic repositioning of some of native and creole species (capulín, walnut and tejocote), trials have been carried out and others are being started in a new regional sustainable fruit development project in the Sierra Nevada.

2. Materials and Methods

The Sierra Nevada region belongs to the Iztaccíhuatl and Popocatépetl volcanoes, and is located in the central western part of the state of Puebla between 2,200 to 3,000 masl (meters above sea level). The dominant farming systems is family farming, which includes a fruit growing component, arranged in wide rows of intermingled trees on the same row (pear, plum, walnut, tejocote, capulín, peach, apple, apricot), which are intercropped with annual crops such as corn, beans and squash (*Cucurbita* sp.), forage crops such as oats (*Avena sativa*) and alfalfa (*Medicago sativa*) and other species (vegetables and flowers), according to the prevailing water condition, either rainfed or irrigation.

In this paper, an analysis of main results and contributions about the fruit component is made, corresponding to the last three stages and major approaches: 1) disciplinary research and technology transfer in fruit trees, 2) biodiversity and productivity of family farming and fruit growing, and 3) technological, social and economic development of the region from the fruit sector [7].

First, research and fruit transfer projects of native species and creole varieties are described and analyzed, under a specialized approach of organic production, as well as projects that include species with improved varieties that are managed with conventional technology (nutrition and control of parasites with the use of commercial inputs), as well as, formation and pruning of trees in the Tatura or vase system, whose actions began from the mid-2000s.

In the last five years the emphasis has been placed on creole and improved fruit trees interspersed with annual crops; through a case study in two plots, the analysis is done under measurement criteria such as the degree of crop diversity and the levels of productivity of both types of species, perennial and cyclical, in the main varieties. It also describes and shows the first advances related to the recent actions (2019) addressed to achieve or contribute to regional sustainable development of the fruit component in the family farm, as an economic activity currently available to family production units (FPU).

3. Results and Discussion

3.1 Research Projects and Transfer of Fruit Production Technology

One project is that of species and varieties of native and creole fruit trees (mainly tejocote and walnut) where the use of organic inputs is being tested, specifically for pest control and other related production factors through foliar fertilization, in

addition to pruning. Also, in the same line, new outstanding varieties have been identified in improved apricot (CP92-1, H3, CP90-17, CP17-10, Morena 1 and Morena 3), which have been characterized by variables such as chill hours, days to flowering, fruit size, flavor and color. In walnut, for example, actions have been addressed to controlling the fly (*Rhagoletis zoqui*) and damage by bacteriosis (*Xanthomona campestris*), in which estimated yields are one thousand nuts on large trees and 600 pieces in medium-sized trees, which have a sale price of more than Mex$ 100 per one cent [8].

In tejocote, the fruit borer (*Conotrachelus crataegi*) and the fruit fly (*Rhagoletis pomonella*) have been identified, and the use of organic products such as Spinosad (natural insecticide) and Ceratrap (biological product and food attractant that is placed in traps) have been studied for biological control, respectively. Also the use of organic foliar fertilizers and application of compost to the soil, in order to obtain good quality fruits and better price, which can be marketed in central states of the country, but also in northern states so that in turn they place this product into american market. In the highest altitude (more than 2,600 masl) in the first months of the year, there is more incidence of fruit fungi such as rust (*Gymnonporangium clavipes*), which has been treated with fungicides, while in the lower stratum (up to 2,300 masl) the fruit borer predominates, causing the fruits to be less marketable.

For this, for several years, technical advice has been given, and participatory and itinerant workshops have been held, which in 2019 were 35 for walnut, tejocote and other species, on various topics: sampling and control of the debarking worm in pine (*Pinus* sp), compost preparation (several workshops for two species), typical winter and rejuvenation pruning (for three species), preparation and application of Bordeaux mixture (copper and lime), foliar application of calcium, control of the fruit fly, organic fertilization, sampling of the borer worm, pest and disease control, green pruning (walnut, tejocote, peach and apple), fruit thinning, application of Vitol (organic growth inducer), fall pruning, harvest and post-harvest handling.

Two other projects are the evaluation of improved peach, apple and apricot cultivars through the use of demonstrative and experimental plots, including commercial orchards, where trees have been treated with less aggressive pesticides (green band) and with conventional fertilizers (commercial). This shows the high potential for increasing yield of these species, which in one community continues to be verified: 27 t/ha in peach and 18 t/ha in apricot (Tables 1-2), and more than 30 t/ha in apple tree in another community, from outstanding cultivars and varieties that have been identified, and are currently available for local farmers. These works began in the early 2010s.

Table 1 Densities and Yields of Commercial Peach and Apricot Orchards in Chiautzingo, Puebla, 2019

No. orchard & species	Cultivation system	Variety	Population density (trees/ha)	Space distribution (m)	No. of fruits per tree	Yield	
						kg/tree	kg/ha
1. Peach	Simple	Diamante Mejorado	1000	5 × 2	227	25	24,970
2. Peach	Interspersed	Chapeado[1]	267	15 × 2.5	1220	84.2	22,476
3. Peach	Interspersed	Chapeado[1]	190	15 × 3.5	1060	72.1	13,695
4. Peach	Simple	Chapeado[1]	1000	5 × 2	435	36.5	36,540
1. Apricot	Simple	Rosana	667	5 × 3	494	23	15,337
2. Apricot	Interspersed	Rosana	333	15 × 2	790	30.8	10,260

[1] Probably corresponds to Diamante Supremo.

Table 2 Fruit size (average large, medium and small), densities and yields adjusted to simple Orchards in Chiautzingo, Puebla, 2019.

No. orchard & species	Population density (trees/ha)	No. of fruits per tree	Fruit weight (g)[1]	Fruit diameter (mm)[1]			Yield	
				Polar	Equatorial 1	Equatorial 2	kg/tree	kg/ha
1. Peach	1000	227	110	55	60	n/a	25.0	24,970
2. Peach (a)	267	1220	69	47	51	n/a	84.2	22,476[2]
2. Peach (b)	800	810	69	47	51	n/a	56.2	44,952[2]
3. Peach	600	403	68	48	51	n/a	45.6	27,390
4. Peach	1000	435	84	55	55	n/a	36.5	36,540
Average (a)	717	468	83	51	54	n/a	38.8	27,844
Average (b)	767	526	83	51	54	n/a	43.6	33,463
1. Apricot	667	326	47	44	40	44	23.0	15,337
2. Apricot	1000	526	39	41	37	42	20.5	20,520
Average	833	417	43	43	38	43	21.5	17,929

[1] Average of the weight and diameter of the fruits of samples obtained to estimate yields (n/a means not applicable).

[2] These yields correspond to the peach orchard intercropped with annual crops and the same orchard as a single crop, respectively.

These results encourage continuing promoting cultivation of peaches, since the drop in production and planted area at the state level in Puebla. In this decade, it is related to other factors besides the negative effect of frost, because even with recurring damage due to early frosts (February and March), in the Sierra Nevada it is possible to get on average 13 to 15 t/ha per year, which are highly profitable productions. Along the frost effect, other factors are linked to productivity decreasing, such as the normal aging of the trees, which were no longer replaced, the size of the orchards (1.0 ha or more), which was associated with expensive investments that small FPU could not afford, as well as, lack of financing and specialized technical advice, which cause the trees not get the most proper management. Table 3 presents some statistical parameters of the variables of weight and diameter of the fruit for each of the improved orchards that were evaluated.

Table 3 Some statistical parameters of fruit weight and size in the peach and apricot orchards in 2019.

Statistical parameter	Fruit weight (g)	Fruit diameter (mm)		Fruit weight (g)	Fruit diameter (mm)		
		Polar	Equatorial		Polar	Equatorial-1	Equatorial-2
	Orchard 1. Peach				Orchard 4. Peach		
No. obs.	9	9	9	5	5	5	n/a
Min	66.3	47.0	49.1	72.5	48.5	52.5	n/a
Max	154.8	63.2	67.9	100.2	59.9	57.0	n/a
Average	110.1	55.4	59.6	83.8	55.0	54.7	n/a
±Std. Dev.	29.0	5.6	5.7	10.3	4.5	1.7	n/a
	Orchard 2. Peach				Orchard 1. Apricot		
No. obs.	5	5	5	14	14	14	14
Min	40.3	40.0	42.0	28.8	35.0	35.0	37.5
Max	80.0	51.5	55.0	64.6	53.0	45.0	51.0
Average	68.5	47.2	50.7	46.6	44.4	40.0	44.4
±Std. Dev.	16.7	4.8	4.9	11.4	4.8	3.3	4.0
	Orchard 3. Peach				Orchard 2. Apricot		
No. obs.	7	7	7	10	10	10	10
Min	56.4	45.0	48.0	30.0	36.5	35.5	38.0
Max	83.8	53.0	54.9	44.4	44.0	41.5	44.5
Average	62.9	46.8	49.4	39.0	40.7	38.6	42.0
±Std. Dev.	9.4	2.6	2.6	5.0	2.4	2.1	2.0

The elements of a technological strategy that were considered, in order to advance the expansion of peach cultivation [9] were: 1) development and monitoring small family nurseries, with a micro-enterprise approach, addressed to the propagation of peach trees using improved varieties; 2) establishment of simple and interspersed orchards under the concept of experimental-demonstrative plots (generation-application of technical knowledge), and continuous and direct technical advice to the participating FPU under an adequate tree management plan (variety, plantation design, pruning, nutrition, control of parasites); and 3) promotion of improved technology developed in the field, and demonstration of the potential yield that is feasible to get with the improved technology, oriented to reach larger tree population and spreading of commercial plantations. This led to significant growth in the established surface of orchards in the 1990s and 2000s [5].

Even though significant productive growth has also been achieved, this has not been enough in quantity and breadth to achieve the potential yield available at the regional level (Sierra Nevada) and at the state of Puebla, especially in increasing fruit quality, in the case of improved peach, thus obtaining better product prices and therefore better income for the FPU. Therefore, in addition to technology, other factors must be considered, as strategic elements referring to social and institutional issues: 4) a wide and efficient system of continue education (training and technical-organizational advice) at two levels (specialist to technical adviser and technical adviser to farmer). 5) better participation of FPU and their organizations for production (plots of no more than 0.5 ha per farmer), storage, commercialization and industrialization, in order to generate greater volumes for sale and greater added value to the fruits, also for the benefit of primary producer (better profits) and the social consumer (lower price), not only intermediaries. 6) financing of participating FPU with subsidy in professional advice during the tree growth phase (public co-financing) and payment of technical advice from the productive phase (self-financing). 7) Suitable technical-financial support from local institutions on production components of the fruit tree value chain by municipalities, federal and state productive development agencies, educational and research institutions, and state produce-system committees [10].

3.2 Biodiversity and Productivity of Family Farming and Fruit Growing

In a case study in the second half of the 2010s made on two irrigated lands in Chiautzingo, Puebla, with a total of 2.4 ha, the fruit trees covered 0.5 ha. In the northern part of the land, there are 9 wide rows (at 10 m) of 100 m in length planted with fruit trees: pear trees (6 rows), creole peaches (3) and tejocote trees intermingled in these rows. In the south-east part there are five wide rows (11-13 m), also 100 m long, with improved apples and in the south-western portion with a row of several species, two of fig (*Ficus carica*), two of peach, one of vine (*Vitis vinifera*), two of apricot and one of pear tree, all these mainly in narrow rows (at 5 m). Among the varieties used and produced for commercial purposes are, on the north side, grafted tejocote (large), kieffer pear (pineapple and other local creole) and creole peach. In the southern portion, apple trees were established with Gala type varieties (Buckey and Royal Gala) whose trees have already been re-grafted with Agua Nueva II, because the Gala did not adapt well (they only yielded 2-3 t/ha), fig of the region, improved peach with red fruit (Oro Azteca), and an improved apricot variety from the Rosana series [11].

Between all the rows of fruit trees, each agricultural cycle is interspersed with rows of annual crops, in different amounts, depending on the width of this space (Fig. 1). The crops that have been intervening in the remaining area of 1.9 ha are corn in simple cultivation, corn associated with squash, corn associated with beans and ayocote (*Phaseolus coccineus*) entangler (long guide varieties), simple crops of bush beans and

ayocote, beans and ayocote on trellises, broad chile pepper (*Capsicum annuum*), amaranth (*Amaranthus* sp.), pumpkin and alfalfa. Population densities and bean and ayocote yields, in its different productive forms, are presented in Table 4.

Apricot (15.3 t/ha)	Bush beans (No est.)[1]	Ayocote on trellises (5.7 t/ha)	Bush beans (No est.)	Pears (No est.)	Bush beans (No est.)	Bean on trellises (3.7 t/ha)	Bush beans (No est.)	Apricot (15.3 t/ha)

[1] (Not estimated). The bush bean was not yet emerging when the photo was taken.

Fig. 1 Example of a family agricultural and fruit system (photo from 07/14/2019 [7]).

Table 4 Grain Yields of bean and ayocote crops intercropped between rows of fruit trees in 2019 (example).

Crops	Variety	Growth habit	Pop. density. (plants/ha)	Yield (kg/ha)[1]
Common bean	Pinto	Determined (bush plant, mata)	112,800	2,050
Ayocote bean	Purple	Determined (bush plant, short guide)	51,200	3,950
Trellis bean	Butter	Indeterminate (entangler, long guide)	32,700	3,660
Trellis bean	Black	Indeterminate (entangler, long guide)	38,500	3,980
Trellis bean	Colours[2]	Indeterminate (entangler, long guide)	42,300	5,720
Trellis ayocote	Colours[3]	Indeterminate (entangler, long guide)	30,800	5,730

[1] Estimate directed to the most productive areas due to drought damage in September (lower than expected grain yields), which is not common (this month is the rainiest of the year). The trellis crops were the most affected (normally, the beans yield above 5 t/ha and the ayocote even more).

[2] Beans with larger grain size and with higher plant density (grain color mix: mottled, butter and black).

[3] Grain color mix: brown, purple, butter, white, etc.

In 2019, bean and ayocote yields suffered significant damage due to a drought that occurred in September (Fig. 2), especially the trellis crops. This is not common because September is the rainiest month, but this year the precipitation was 40% less than the average, while the months of August and October were 39 and 97% rainier, respectively. Inclusively, the presence of more rain in these months is detrimental to beans, because in August it contributes to a greater presence of weeds and in October to the staining and rotting of pods and grain, mainly in the species of shrubby habit.

Corn area decreased because of low price in this stage (3-4 Mex$/kg of grain), reaching in 2019 no corn planted in these plots. And because corn production costs were higher, and this seems hard to reverse, even with the actual guarantee price (5.6 Mex$/kg of corn) that the new government of Mexico is offering [14]. On

the other hand, an increase in the areas planted with ayocote, amaranth and beans due to their better sale price (15 Mex$/kg) and because the cultivation costs of these species are lower, as well as a drop in the surface of chile pepper due to a root disease that affects this species (sadness caused by a complex of fungi and nematodes), even though the prices and profits in this crop are even better (Fig. 3)

In the two plots, 6 species of fruit trees and 7 of annual and forage crops are available for commercial purposes, in which there are 20 varieties in both types of crops. The evaluation of the fruit trees productivity,

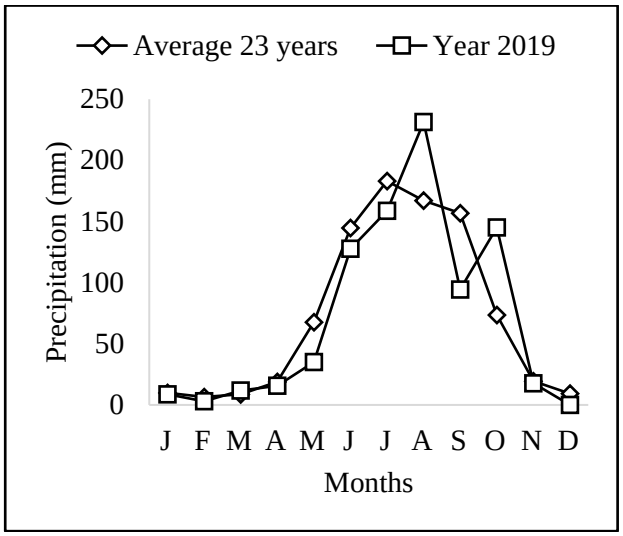

Fig. 2 Distribution of Rainfall at Huejotzingo, Puebla [12, 13].

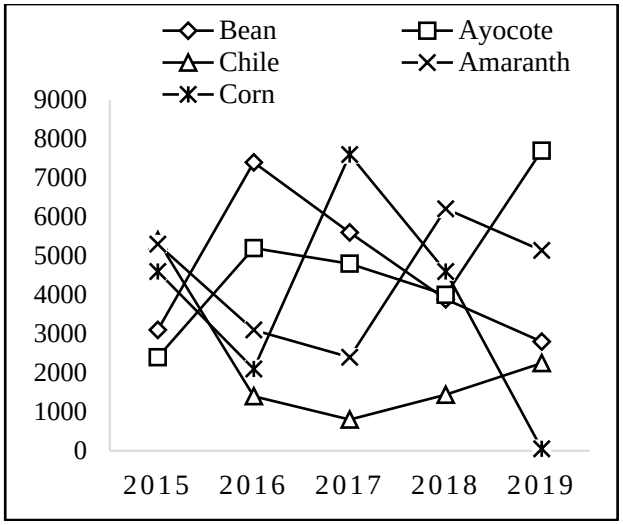

Fig. 3 Trends in Established Area (m^2) of Intercropping Crops Between Fruit Trees Rows in Five Years.

in general has been satisfactory, for example, in the parts of land covered by the commercial improved peach orchard with Diamante varieties (yellow fruit) and Oro Azteca (red fruit), in an earlier period of four years, with strong early frosts, which decreased production on average 46%. The average yield was 10.8 t/ha and the benefit/cost ratio 2.0 [15]. Recently, productive performance of the peach has turned out to be better, in 2019 the average yield in four different orchards in the community was 27 t/ha, while in apricot 18 t/ha were harvested in two commercial orchards in full production (Table 2).

The above numbers have been achieved due to tree management plan that farmers have followed, with this, the quality of the fruit has also been improved (size, color and flavor), and this in turn, has resulted in an increase in price of peach (50-100%) in the local-regional market of Huejotzingo. With annual investments of around Mex$ 50/tree in five rows of 100 m (0.25 ha) of peach trees, considering a produce price to the farmer of Mex$ 9/kg and a production cost of 10,000 pesos, profit is 14,000 pesos and benefit/cost ratio of 2.4, which indicates the high profitability that peach cultivation still have.

3.3 Regional Sustainable Fruit Development Project Just Started

Related to native and creole fruit trees, recently (2019) in deep contact and monitoring actions have been started with the FPU, specifically through training workshops, forums with significant participation of farmer organizations, local authorities and institutional representatives, and a base line study with a survey from a probabilistic sample in the region, as part of a new proposal: “Development and Soil Restoration Project for Improving Sustainable Fruit Productivity and Competitiveness in the Sierra Nevada Region of Puebla” (Table 5). This has allowed focusing in a first stage on Castilla walnut, tejocote and capulín, considering that farmers’ organizations have already been established for production and marketing of these three species.

Table 5 Workshops, forums and field tours on fruit development and management in 2019 (pruning, nutrition, pests and diseases control, other topics) and references available for fruit species.

Date	Municipality	Event	Atendance	Species	No. references[1]
Jan-11	Huejotzingo	Fruit trees-peach workshop	22	Peach	20
Feb-07	S.P. Cholula	Regional fruit trees forum	200		
Feb-20	Huejotzingo	Fruit production workshop	25	Apple	5
Feb-27	Los Ranchos	Fruit prod. workshop-walnut	27		
Mar-05	S.A. Calpan	Fruit trees workshop-tejocote	40	Fruit trees	10
Mar-08	Dom. Arenas	Fruit trees workshop-capulín	26		
Mar-19	Huejotzingo	Fruit trade-transformation	11	Walnut	11
Mar-22	S.S. El Verde	Tejocote product. workshop	30		
Mar-26	Dom. Arenas	Capulín Mexican flye control	80	Apricot	3
May-06	Huejotzingo	Fruits and flowers forum	150		
May-29	Huejotzingo	Field tour avocado orchards	25	Capulín	1
Jun8-9	Dom. Arenas	1st Capulín fair-processing	>300		
Jul-22	Huejotzingo	Field tour avocado orchards	40	Tejocote	5
Jul-24	S.S. El Verde	Cooperatives workshop	19		
Aug-21	S.S. El Verde	Cooperatives workshop	18	Pears	1
Aug-29	Chiautzingo	Workshop on diagnosis	22		
Aug-30	Los Ranchos	Workshop on diagnosis	28	Total	56
Sep-08	Huejotzingo	1st Berry fair-products &process	> 400		
Sep-04	S.S. El Verde	Workshop on diagnosis	26		
Sep-13	S.A. Calpan	Workshop on diagnosis	35		
Sep-19	Teotlalcingo	Workshop on diagnosis	36	Others: technical reports and activities	
Oct-15	Huejotzingo	Avocado cultivation meeting	35		
Oct-16	S.S. El Verde	Cooperatives workshop	23		
Oct-22	Huejotzingo	Citizen participation forum	130		
Oct-25	Teotlalcingo	Fruit trees conference	70		
Nov-06	S.S. El Verde	Survey interviews	25	Others: information on posters	
Nov-14	Chiautzingo	Survey interviews	20		
Nov-17	S.A. Calpan	13[a] Tejocote fair-processing	>500		
Nov-26	Huejotzingo	Avocado cultivation meeting	15		
Dec-02	Huejotzingo	Avocado cultivation meeting	18	Others: personal research files and field books	
Dec-02	Huejotzingo	Survey interviews	18		
Dec-07	Zecalacoayan	1st Tejocote fair-processing	30		
Dec-09	Huejotzingo	Field tour avocado orchards	13		

Source: Made with field, forum, fairs, meetings and references databases.

[1] Bibliographic citations of works carried out in the region (books, chapters, manuals, articles, theses, others), mainly concentrated on [13].

3.3.1 First Period of 2019

Therefore, the initial actions in these crops (including peach) were oriented to itinerant participative workshops with technicians and farmers, through field trips and work meetings [7]. In these events, theoretical and practical topics of production technology (pruning, natural charcoal elaboration with pruning residues for tree nutrition, protection against parasites based on organic products), ways of collecting rainwater and the required institutional services are addressed. Also actions to establish a collection center and the commercialization of pear and

tejocote, adding value in capulín through semi-industrial processes on pulping, seed conditioning and winemaking, among others.

As the Official Mexican Norm (NOM) for Castilla walnuts has already been created and the production chain in the Sierra Nevada has been integrated [16], this crop is being promoted to respond to the current great demand for the regional deli dish called "chiles en nogada": about three million chilies per year according to the National Chamber of the Restaurant Industry (CANIRAC) in Puebla. Actions have been addressed to phytosanitary issues, especially control of the walnut fly.

In tejocote there have been remarkable advances in orchard management and production destiny, going from very poorly managed orchards and whole sales of gravel (waste fruit) for the juice industry (2 Mex$/kg), to the production of good quality fruit (larger size) achieving better price, and even export to the United States (with prices of up to 25 Mex$/kg). This has required incorporation of key productive practices in the orchards, such as pruning and nutrition, pest control measures such as the Mexican fly and the borer of the fruit, and producing safely, thus marketing hundreds of tons per agricultural cycle in recent years.

In the case of capulín, which had not been given the necessary importance and trying to recognize the importance and potential of this fruit, in the municipality of Domingo Arenas, a trapping practice was carried out to capture fruit flies (*Rhagoletis cingulata*), using a natural extract of chicalote (*Argemone mexicana*) mixed with water and sugar, which trees also have mistletoe (parasitic plant) and algae on the stems, stem borer, affections of bacteriosis (drying of branches and leaves) and leaf spots (*Alternaria*). At the First Capulin Fair in the town of Domingo Arenas, it was possible, on the one hand, set criteria to define topics for study and research, in order to facilitate initial actions for developing the value chain of capulín.

The subjects identified were: 1) morphological characterization of the fruit (variety, weight, size, bone hardness, etc.); 2) collect information to develop socioeconomic analyzes (productive diagnosis, profitability analysis); 3) value adding processes to production in pulp and bone (food produce for sale); 4) farmers' organization for production, financing, transforming and marketing; 5) improvement of technological and productive aspects (grafting, pruning, nutrition, integrated pest management and diseases); and 6) the component of natural resources, related to environmental services contributing to restoration of soils in the areas of physics (erosion control, enrich moisture content), fertility (use of mineral fertilizers, organic matter, charcoal-ash), chemistry (pH, CEC, EC), microbiology (biofertilizers), the use and conservation of water with small hydraulic constructions and with the contribution of greater capture of atmospheric CO_2 through better management of trees.

On the other hand, it was possible to get documental information [17] and from the FPU about some production and transformation process, as well the kind of products made from the capulín fruit, in artisanal way. Typically, the fruit pulp is removed to use the bone (seed) for sale, or a proportion of fruit is sold fresh, so most of the pulp is wasted. The pulp that is used, is used to prepare wines, jams and other foods; the bone is roasted on griddles (artisanal way) and salt is added; however, tests have already been made to produce higher volumes (semi-industrial production), for which it is being proposed to use motorized equipment (rotating pots and burners) and stainless steel materials.

Typically the FPU have at least 30 large capulín trees, but those with 100 are very common, and some of them have up to 2000 (these growing). Once the fruit is harvested it is sold fresh, but an important production are pulped by light motor equipment (electric), and the pulp is discarded to use the bone, since the market is only being explored and the possibility of a greater use

of the pulp. The fresh fruit is sold in 8 kg buckets at a rate of Mex$ 100 (12 Mex$/kg), while the natural bone (30% of the fruit), that is the way in which this species is most used, is sold at 60 Mex$/kg, and already toasted at 80 Mex$/kg. Considering a FPU with 30 large trees in full production and a yield per tree of 50 kg, the analysis shows an income of 3,000 Mex$/tree and Mex$ 90,000 per year per family.

Presentation of capulín bones (seeds) for sale is varied: with salt (whitish color), garlic and red chile pepper (brown color), with jalapeño pepper (green color), chipotle chile pepper (red color) and with a sweet base for candys. Table wine is made from the pulp (one kg of fresh fruit for 5 liters of wine), jam, jelly and tamales, honey and chamoy fruits are prepared; empanadas, cakes, pies, tartlets and other flour-based products are also made. These products, along with the income from sales of the primary produce, give an idea of the economic and social value, and potential use that can be given to the capulín fruit in the region.

3.3.2 Second Period of 2019

In this period, the main three activities carried out were (Table 5):

1) Participatory classroom workshops (interactive) on the diagnosis of socioeconomic and agricultural activities carried out by farmers, mainly on fruit production. This, as a way of providing first-hand information for planning rural research and development initiatives, and for designing of productive projects aimed at technical-economic support for the family and ways of public co-financing investment proposals from the farmers. In addition, workshops to provide information on the constitution of formally organized groups, which is a requirement to access government programs, under the criteria of cooperatives, which are less expensive than other associative figures.

2) The test of questionnaires also were carried out and its application continues in the municipalities of the region, in order to establish the base line of the fruit development project, and to have more information, which will allow establish the monitoring and evaluation system for the project, once the operational component has started. As a result, technical studios (summaries) of projects on demonstration and technology transfer plots in fruit trees, commercialization processes and value addition, were prepared. This for different species and municipalities and the productive projects are currently in process (justification, location, production, markets, economic indicators, feasibility analysis, etc.), in subjects like: propagation of improved plants in nursery, establishment of orchards with native varieties, orchards with improved varieties interspersed with annual crops, marketing (fruit collection center), industrialization of fruit products, among others.

3) In addition, participation in the first “capulin” fair, in the first berry fair (mainly about raspberry and blackberry), in the 13th tejocote fair in one community and in the first tejocote fair in another community. The contributions of the project workforce team in these cases were: event organization and participation as guest in the presidium, exhibition of research and transfer projects in posters, conferences, interviews with exhibitors, promotion of the fruit project, advice to farmers, etc. As well as a talk on fruit trees at an annual meeting of forest ejidos of the region, presentation of the fruit project in a citizen participation forum of the state government of Puebla on “recovery of the field” and in various work meetings and field trips through avocado (*Persea americana*) orchards.

So another crop that has been promoted in fields of one community is avocado, as part of the research and extension program in the Sierra Nevada by the Huejotzingo Priority Attention Microregion (PAM) [13]. This resulted by the interest of a farmers’ organization to start activities on this specie in 2018, and after a good experience of a member of these group. This was possible with financial support from a Non-Governmental Organization, which provided aid

for the acquisition of several thousands of improved plants. Actions in avocado have been related to the following topics: collaboration activity planning and planting of trees. Organization process of farmers, already legally constituted. Advising on some technical subjects of cultivation, and building small constructions to collect rainwater (cisterns and tanks locally called water pots), from surface runoff that occurs during the rainy season, which have been installed besides of avocado orchards.

4. Conclusion

In projects with disciplinary research and technology transfer, focus were oriented to organic management of native and creole species (tejocote and walnut), but also to the testing, selection and promotion of improved varieties of fruit trees such as peach, apple, apricot, pear and others.

In walnut and tejocote, the work has been aimed at pruning and nutrition of trees and pest control (borers of fruit and the Mexican fly), under natural and organic management, addressed to improve the quality of the produce and get a healthy production, given the current high demand for walnuts to make chiles en nogada and to market tejocote in the north of the country and in the United States, as alternatives to the low-quality tejocote that has been used as gravel (waste) by the national juice industry.

In 2019 results indicate that it was possible, through conventional technologies, to produce with great success improved fruit with average yields, in one community 18 t/ha of apricot and 27 t/ha of peach, and in another community more than 30 t/ha of apple, with good fruit quality (weight, size, flavor). Confirming the potential yield that had been previously estimated in these species, under normal environmental conditions (years without severe early frosts).

It is concluded that a high degree of agricultural biodiversity is present, in the case of two plots established for five years for commercial production purposes (6 fruit species intercropped with 7 annual and forage crops and 20 varieties in total), as well as high productivity in the main fruit and annual species grown on 2.4 hectares.

These results and the importance that the use of native species and creole varieties are currently recovering, to be used in the culinary art and in gastronomy of Puebla, or for sales in better markets and export purposes, has justified that the actions complement each other and refocus on the capulín fruit (which has not been given the importance of its potential), walnut and tejocote in a new project for regional fruit development that is just beginning and that offers the perspective of studying the sustainability of fruit growing in its economic, social and environmental aspects.

The yields of the annual crops intercropped in the fruit trees, mainly under good weather conditions (rain), turn out to be high: bush beans more than 2 t/ha, bush ayocote and amaranth more than 4 t/ha, beans on trellis more than 5 t/ha, ayocote on trellis more than 6 t/ha, hybrid corn more than 7 t/ha, and irrigated hybrid corn more than 9 t/ha. With an increasing trend in the area with ayocote, amaranth and beans, for their better market price, and a downward tendency in the case of corn, due to higher production cost and lower market price, and in chile pepper for management problems like root diseases.

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Improving Nutrient Recovery of *Zea Mays* L. Using Paddy Husk Compost and Clinoptilolite Zeolite

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Abstract: Co-application of inorganic fertilizers and paddy husk compost at different rates amended with clinoptilolite zeolite using maize as a test crop were tested in a pot study to determine their effects on: (i) selected soil chemical properties and (ii) nutrients recovery of maize. A pot study was carried out for 45 days (tasselling stage). The treatments evaluated were: Soil only (T0), 7.40 g urea + 5 g TSP + 3.80 g MOP (T1), 7.40 g urea + 5 g TSP + 3.80 g MOP + 192 g zeolite + 192 g compost (T2), 5.55 g urea + 3.75 g TSP + 2.85 g MOP + 192 g zeolite + 385 g compost (T3), 3.70 g urea + 2.50 g TSP + 1.90 g MOP + 192 g zeolite + 577 g compost (T4) and 3.70 g urea + 2.50 g TSP + 1.90 g MOP + 577 g compost (T5). Co-application of inorganic fertilizers with paddy husk compost and clinoptilolite zeolite improved soil total N, exchangeable Ca, Mg, K, available P, and recovery of P and K. Soil chemical properties and productivity of maize can be improved by adopting co-application of inorganic fertilizers with paddy husk compost and clinoptilolite zeolite.

Key words: chemical fertilizers, organic amendment, nutrients availability, nutrients efficacy

1. Introduction

Highly weathered soils (Oxisols and Ultisols) in the humid tropics are low in nutrients holding capacity because most of the minerals with significant negative charges are lost through weathering leaving behind very low charged crystalline minerals in the soils [1]. Modern agriculture depends on the use of inorganic fertilizers to improve crop production. Synthetic fertilizers, in particular are able to increase crop yield because they add nutrients to soils [2]. Inorganic fertilizers for instance, are important inputs in agriculture as they increase crop yield especially in systems where soil resources are deficient in nutrients and the main goal is to increase crop productivity [3]. However, over-reliance on the use of inorganic fertilizers practice which degrades soil quality decreases soil productivity and crop yield over time [4, 5]. Nutrient run-off *via* leaching from agricultural fields degrades aquatic and terrestrial ecosystems and also the quality of groundwater [6-8]. Various approaches had been carried out on the use of available and renewable resources of plant nutrients to complement and supplement inorganic fertilizers. As a result, efforts had been put in place to evaluate the feasibility and efficacy of organic residues, not only to enhance soil productivity but also to promote efficient use of inorganic fertilizers [9].

The effects of compost application on soil properties in the short and long term are well documented. Composts can be used to enhance soil productivity by

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providing organic matter and biological cycle of nutrients which are crucial to the success of managing acid soils. The use of composts in agriculture does not only enhance retention of nutrients in inorganic fertilizers but they also supply nutrients to crops besides supporting rapid nutrients cycling (through microbial biomass) [10]. Compost derived from co-composting paddy husk and chicken slurry is one of the appropriate organic amendments for managing agricultural wastes generated in the rice milling and poultry industries [11]. Co-application of composts and inorganic fertilizers is considered a more environment-friendly way of achieving sustainable agriculture as this approach increases nutrients availability and crop yield [12-15]. It is important to note that sole application of organic amendments such as composts does not support the entire growth and development of most crops because these organic amendments are generally low in plant nutrients [16]. Therefore, including clinoptilolite zeolite in nutrients availability management in soils is essential as this approach ensures retention of crop nutrients from being leached.

Clinoptilolite zeolite has a three-dimensional crystal lattice, with loosely bound cations, capable of hydrating and dehydrating without altering the crystal structure [17]. The shape, dimensions, and linkage of clinoptilolite zeolite pores and voids are the special features of the clinoptilolite zeolite materials [18]. According to Mumpton (1999) [18], the pores and interconnected voids of clinoptilolite zeolite are occupied by cations and water molecules. This mineral has large open channels in the crystal structure that provides void space for adsorption and exchange of cations [14 15]. For example, clinoptilolite zeolite had been used to improve plant growth, yield of *Zea mays* L., and fertilizer use efficiency because of the unique properties of clinoptilolite zeolite [14, 15, 19, 20]. Although the use of clinoptilolite zeolite improves soil quality and crop productivity, there is dearth of information on the use of optimum rates of inorganic fertilizers and paddy husk compost with clinoptilolite zeolite as an additive to improve soil chemical properties and productivity of crops cultivated on highly weathered acid soils. To this end, we hypothesized that amending inorganic fertilizers with paddy husk compost and clinoptilolite zeolite will improve soil chemical properties, nutrients uptake, and recovery of *Zea mays* L. cultivation on acid soils. Thus, a pot study was carried out to determine the effects of amending inorganic fertilizers with paddy husk compost and clinoptilolite zeolite on: (i) soil total N, exchangeable Ca, Mg, K, NH_4^+, available NO_3^-, available P, total organic C, and organic matter, and (ii) N, P, and K uptake and recovery of *Zea mays* L.

2. Materials and Methods

2.1 Soil Selected Physical and Chemical Properties

The soil used in pot study was Bekenu Series (*Typic Paleudults*) and it was collected at 0-20 cm depth from an uncultivated area at Universiti Putra Malaysia Bintulu Campus Sarawak, Malaysia. The soil was air dried and ground to pass a 2 mm sieve for initial characterization and pot experiment. Soil texture, field capacity, and bulk density were determined using the method described by Tan (2005) [21]. The pH of the soil was determined in a ratio of 1:2 (soil: distilled water suspension) using a pH meter. The soil total C, N, and organic matter were determined using Leco CHNS Analyzer (LECO Truspec Micro Elemental Analyzer CHNS, New York). Soil available P was extracted using the double acid method [21] followed by the molybdenum blue method [22]. Exchangeable cations were extracted using the leaching method [21] and thereafter, their contents were determined using Atomic Absorption Spectrophotometry (Analyst 800, Perkin Elmer, Norwalk, USA). Soil CEC was determined using the leaching followed by steam distillation [21]. The method of Keeney and Nelson (1982) [23] was used to extract exchangeable NH_4^+ and available NO_3^- after which their concentrations were determined using steam distillation.

The texture of the soil was sandy loam with a bulk density of 1.51 g cm^{-3}, fine loamy, siliceous, isohyperthermic, with a colour of red-yellow to yellow. It has an argillic horizon with fine sandy clay loam textures. The structure is generally weak medium to coarse sub angular blocky. It is friable in nature [24]. These physical properties are consistent with those reported in Soil Survey Staff (2014) [25]. The selected chemical properties of the soil are summarized in Table 1. The soil pH, total N, and total C are also consistent with those reported for Bekenu series by Paramanathan (2000) [24] whereas exchangeable Ca, Mg, and K are higher than those reported by Paramanathan (2000) [24].

Table 1 Selected chemical properties of Bekenu Series (*Typic Paleudults*).

Property	Value obtained (Mean ± S.E.)	Standard data range
CEC ($cmol_c$ kg^{-1})	7.43 (± 0.15)	8.0-24
pH_{water}	4.66 (± 0.10)	4.60
Exchangeable calcium ($cmol_c$ kg^{-1})	1.41 (± 0.05)	0.01
Exchangeable magnesium ($cmol_c$ kg^{-1})	1.53 (± 0.05)	0.21
Exchangeable potassium ($cmol_c$ kg^{-1})	0.60 (± 0.02)	0.19
Total Nitrogen (%)	0.15 (± 0.01)	0.04-0.17
Organic matter (%)	2.06 (± 0.10)	nd
Total carbon (%)	1.20 (± 0.60)	0.57-2.51
Available phosphorus (mg kg^{-1})	4.16 (± 0.13)	nd
Exchangeable ammonium (mg kg^{-1})	19.85 (± 0.68)	nd
Available nitrate (mg kg^{-1})	5.16 (± 0.09)	nd

Standard data range reported by Paramanathan (2000) [24]; nd: not determined. Values in parenthesis represent standard error of the mean.

2.2 Chemical Characteristics of Paddy Husk Compost

The standard procedures used to characterize the paddy husk compost and their chemical properties are reported in our previous paper [11]. Humic acid, ash, NH_4^+, NO_3^-, P, Ca, Mg, and K contents of the paddy husk compost are relatively high (Table 2). The lower contents of Cu, Fe, Mn, Zn, and microbial population of the paddy husk compost suggest that the compost is stable, mature, and not toxic [11]. The chemical properties of the humic acids extracted from the paddy husk compost and reference values [26] are given in Table 3.

2.3 Chemical Properties of Clinoptilolite Zeolite

The clinoptilolite zeolite used in this study was in powder form. Total N of the clinoptilolite zeolite was determined using Kjeldahl method [27]. The pH, exchangeable NH_4^+, and available NO_3^- of the clinoptilolite zeolite were determined using the method described previously [23, 28]. The CEC of the clinoptilolite zeolite was determined using the CsCl method [17]. The CsCl method was used to avoid underestimation of CEC of the clinoptilolite zeolite as this method does not lead to entrapment of NH_4^+ in the channels of the clinoptilolite zeolite. The exchangeable K, Ca, and Mg contents of the clinoptilolite zeolite were extracted using the method of Ming and Dixon (1986) [17] and their contents determined using Atomic Absorption Spectrophotometry (Analyst 800, Perkin Elmer, Norwalk, USA). The chemical properties of the clinoptilolite zeolite used in this study are summarized in Table 4.

2.4 Pot Experiment

A pot experiment was conducted in a net house at Universiti Putra Malaysia Bintulu Sarawak Campus, Malaysia using completely randomized design (CRD) with three replications. Size of the pots used was 22 x

28 cm. Each pot was filled with 8 kg soil (based on soil bulk density). Maize (*Zea mays* L.) hybrid F1

Table 2 Selected physico-chemical properties of paddy husk compost.

Property	Value obtained (Mean ± S.E.)
pH value	7.9 (± 0.03)
CEC ($cmol_c\ kg^{-1}$)	176 (± 3.17)
Humic acid (%)	5.7 (± 0.03)
EC ($ds\ m^{-1}$)	1.2 (± 0.02)
Total carbon (%)	28.2 (± 0.52)
Organic matter (%)	47 (± 0.55)
Total nitrogen (%)	1.6 (± 0.03)
C/N ratio	17
Ammonium	362 (± 2.92)
Nitrate	172 (± 1.85)
Total phosphorus	1097 (± 0.88)
Calcium	15, 080 (± 0.88)
Magnesium	15, 149 (± 1.85)
Potassium ($mg\ kg^{-1}$)	27, 150 (± 9.87)
Sodium	14,001 (± 2.48)
Iron	3.6 (± 0.14)
Zinc	11.2 (± 0.17)
Copper	2.4 (± 0.11)
Manganese	2.1(± 0.12)
Ash content (%)	6.4 (±0.29)
Moisture content (%)	44 (±0.71)

Values were obtained from our previous study on co-composting paddy husk and chicken manure [11]. Value in parenthesis represent standard error of the mean. Carbon to N ratio was calculated by dividing the percentage of C with the percentage of N.

Table 3 Selected chemical properties of humic acids extracted from paddy husk compost.

Property	*Value obtained (Mean ± S.E.)	Tan (2003)
E_4/E_6	7.78 (± 0.03)	7-8
Phenolic ($cmol_c\ kg^{-1}$)	350 (± 5.54)	240-540
Carboxyl ($cmol_c\ kg^{-1}$)	400 (± 10.68)	150-440
Total acidity ($cmol_c\ kg^{-1}$)	750 (± 5.03)	500-700

E_4/E_6 (optical density) is the absorbance at two arbitrary selected wavelengths (extinction at 465 and 665 nm). The E_4/E_6 is the value of humic acid that indicate humification level of humic acid and it is widely used as an indicator for evaluating the maturity of compost. Values in parenthesis represents standard error of the mean. *Value obtained from previous [11].

Table 4 Selected chemical properties of clinoptilolite zeolite.

Property	Present study (Mean ± S.E.)	Reference*
pH	6.80 (± 0.03)	8-9
CEC ($cmol_c\ kg^{-1}$)	100.33 (± 0.35)	160
Total nitrogen (%)	1.18 (± 0.04)	1.36
Calcium	18,400 (± 19.09)	25, 600
Magnesium	11,200 (± 4.48)	15,000
Potassium ($mg\ kg^{-1}$)	14,850 (± 10.17)	22,600
Ammonium	12.60 (± 0.43)	nd
Nitrate	11.58 (± 0.18)	nd

CEC: Cation exchange capacity; nd: not determine; *Data were obtained from Luxurious Empire Sdn. Bhd., Kulai Jaya, Malaysia. Values in parenthesis represent standard error of the mean.

variety was used as test crop. The N, P, and K requirement of the test crop were 60 kg N, 60 kg P_2O_5, and 40 kg K_2O (130 kg ha^{-1} urea: 130 kg ha^{-1} TSP: 67 kg ha^{-1} MOP) [29]. The fertilizer requirement was scaled down to per pot basis and this was equivalent to 7.40 g of urea, 5 g of TSP, and 3.80 g of MOP. The volume of water used for each pot was based on field capacity (65%).

The treatments evaluated were:

1) Soil only (T0)
2) 7.40 g urea + 5 g TSP + 3.80 g MOP (T1)
3) 7.40 g urea + 5 g TSP + 3.80 g MOP + 192 g zeolite + 192 g compost (T2)
4) 5.55 g urea + 3.75 g TSP + 2.85 g MOP + 192 g zeolite + 385 g compost (T3)
5) 3.70 g urea + 2.50 g TSP + 1.90 g MOP + 192 g zeolite + 577 g compost (T4)
6) 3.70 g urea + 2.50 g TSP + 1.90 g MOP + 577 g compost (T5)

The rates of the clinoptilolite zeolite [30] and paddy husk compost [31] were scaled down from the standard fertilizer recommendation for *Zea mays* L. cultivation. The amounts of the paddy husk compost used were based on 5, 10, and 15 tonnes ha^{-1} and scaled down to per plant basis which were equivalent to 192 g, 385 g,

and 577 g of the compost [31]. The amounts of the inorganic fertilizers used in T3 and T4 were reduced by 25 and 50%, respectively and this was based on the amount of paddy husk compost used to compensate the requirement of the test crop. The paddy husk compost and clinoptilolite zeolite were mixed with soil a day before planting. The inorganic fertilizers (equal amount) were applied twice that is, 10 and 28 days after planting. Soil only (T0) without addition of fertilizers was used to calculate nutrient efficiency which is defined as the amount of fertilizer taken up and used by plant versus the amount of fertilizer lost [32].

At 45 days after planting (tasseling stage), the *Zea mays* L. plants were harvested. Tassel stage is the maximum growth stage for the plant before it goes to reproductive stage [33]. At 45 days after planting, plants were partitioned into stem, leaf, and root. The root in the soil were removed carefully and washed using tap followed by distilled water. The leaf, stem, and root were oven dried at 60°C until constant weight were attained and their dry weight were determined. Each of the maize plant part was ground and analyzed for total N, P, and K uptake and N, P, and K use efficiency. Total N of the plant tissues was determined by the Kjeldahl method [27]. Potassium of the plant tissues was obtained by digesting the tissues using the dry ashing method [21] after which the extracts were analyzed using AAS. Phosphorus of the plant tissues was extracted using the dry ashing [21] followed by the molybdenum blue method [22]. At 45 days after planting, soil samples were analyzed for soil total N, pH, exchangeable NH_4^+, available NO_3^-, exchangeable cations, and available P using the standard methods as previously outlined [21-23, 27, 28]. Nitrogen, P, and K uptake in leaf, stem, and root were determined by multiplying their concentrations with the dry weight of the plant parts.

Nitrogen, P, and K recovery were determined by the equation described by Dobermann (2005) [32]:

$$\text{Nutrient recovery}\,(\%) = \frac{(\text{Uptake with fertilizer} - \text{Uptake without fertilizer}) \times 100}{\text{Total amount of fertilizer that had been applied}}$$

2.5 Experimental Design and Statistical Analysis

The experimental design of the pot study was completely randomized design (CRD) with three replications. Analysis of variance (ANOVA) was used to detect treatment effects whereas Tukey's test was used to compare treatment means at $P \leq 0.05$. The Statistical Analysis System version 9.2 was used for the statistical tests.

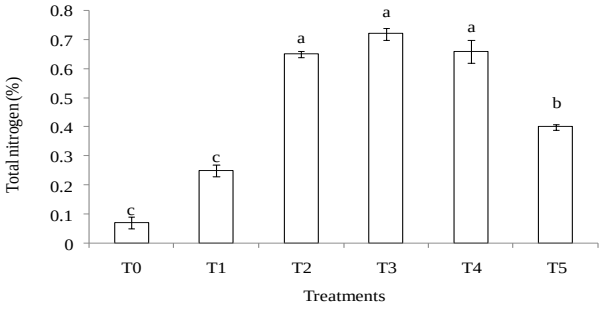
3. Results

3.1 Soil Chemical Properties at forty Five Days After Planting

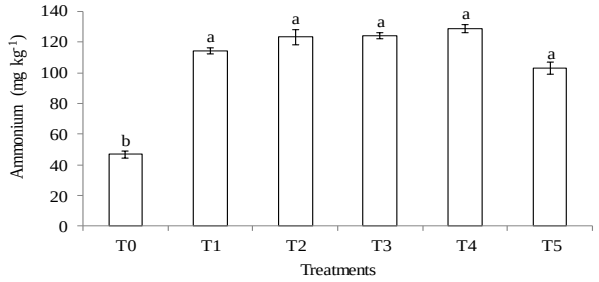
The treatments with paddy husk compost and clinoptilolite zeolite (T2, T3, T4, and T5) had significant effects on soil total N at 45 days after planting compared with that of soil only (T0) and soil with inorganic fertilizers only (T1) (Fig. 1). The soil exchangeable NH_4^+ and available NO_3^- were not affected by the addition of paddy husk compost and clinoptilolite zeolite (Fig. 1). However, soil exchangeable Ca, Mg, K, and available P were significantly improved in the all treatments with paddy husk compost and clinoptilolite zeolite (T2, T3, T4, and T5) compared with the treatment without paddy husk compost and clinoptilolite zeolite (T1) (Table 5). Co-application of inorganic fertilizers with the highest rates of paddy husk compost affected soil pH at 45 days after planting (Fig. 2). The pots with inorganic fertilizers only (T1) and those with inorganic fertilizers, paddy husk compost, and clinoptilolite zeolite (T2, T3, T4, and T5) showed no significant effect on soil total organic C and organic matter (Fig. 3).

3.1 Dry Weight, Nutrient Uptake, and Nutrient Recovery of Zea Mays L.

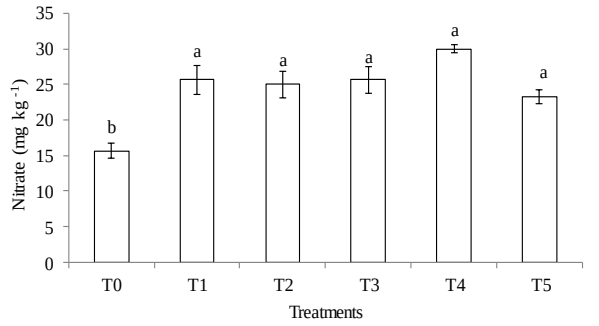
Dry weight of *Zea mays* L. stem were significantly higher in T2, T4, and T5 compared with T1 (Fig. 4a). For leaf, the highest dry weight of *Zea mays* L. was observed in T4 (Fig. 4b), whilst no significant effect was detected for the dry weight of root of T1, T2, T3,



(a) Soil total N at 45 days after planting.



(b) Soil exchangeable ammonium at 45 days after planting.



(c) Soil to available nitrate at 45 days after planting.

Fig. 1 Soil total N, exchangeable ammonium, and available nitrate at 45 days after planting. Bars with different letters are significantly different at by Tukey's test at $P \leq 0.05$.

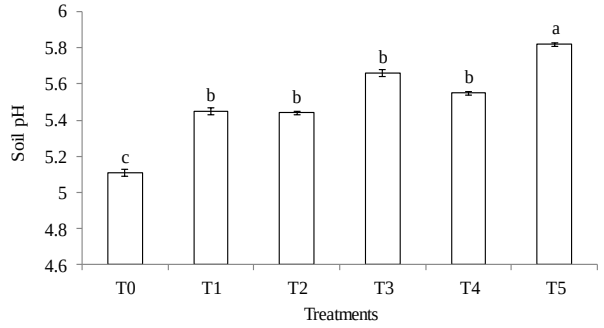
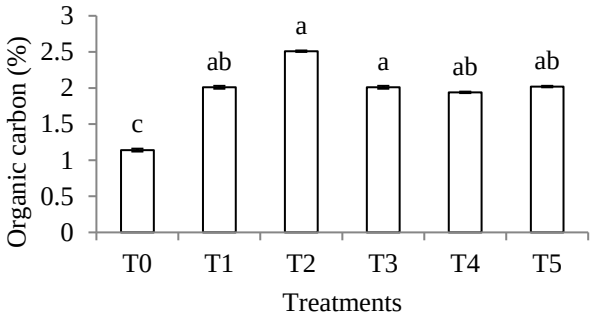
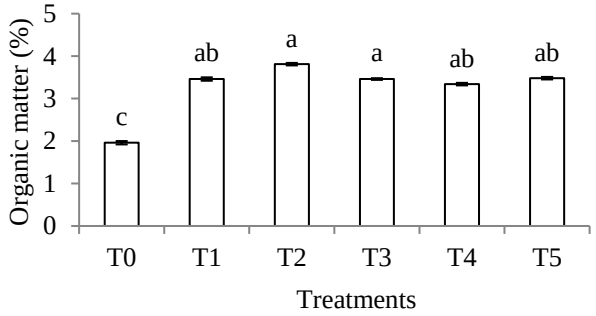


Fig. 2 Soil pH at 45 days after planting. Bars with different letters are significantly different by Tukey's test at $P \leq 0.05$.



(a) Soil organic carbon at forty five days after planting.



(b) Soil organic matter at forty five days after planting.

Fig. 3 Soil organic carbon and organic matter at forty five days after planting. Bars with different letters are significantly different by Tukey's test at $P \leq 0.05$.

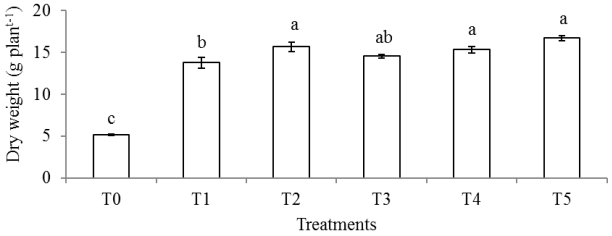
Table 5 Selected soil chemical properties at 45 days after planting maize.

Treatment	Ca	Mg	K	P
	(mg kg^{-1}) Mean (S.E.)			
T0	1.42^{c} (±0.69)	1.22^{d} (±0.08)	0.79^{d} (±0.08)	3.26^{d} (±0.20)
T1	1079.67^{b} (±3.52)	1329^{c} (±2.88)	2054.3^{c} (±4.80)	1112^{c} (±1.15)
T2	1259^{a} (±3.84)	1482^{a} (±2.02)	2255^{a} (±1.76)	3230^{a} (±2.02)
T3	1288^{a} (±2.08)	1419^{b} (±0.57)	2244^{b} (±8.35)	3219^{a} (±0.88)
T4	1261^{a} (±1.73)	1366^{c} (±1.20)	2297^{a} (±8.41)	2316^{b} (±2.08)
T5	1214^{c} (±2.40)	1394^{c} (±3.38)	2281^{a} (±5.23)	2128^{b} (±2.08)

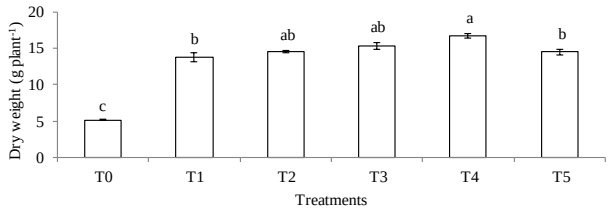
Means followed by the same letter are not significantly different based on Tukey's test at $P \leq 0.05$. S.E. is standard error of the mean which included in parenthesis.

T4, and T5 (Fig. 4c). Similar effect on N uptake of *Zea mays* L. was observed in application of inorganic fertilizers only (T1) and co-application of inorganic

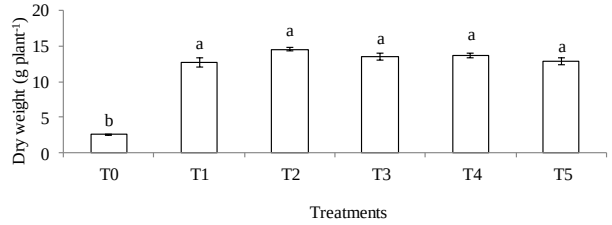
fertilizers, paddy husk compost, and clinoptilolite zeolite (T2, T3, T4, and T5) (Fig. 5a). However, for P and K uptake, the pots with paddy husk compost and clinoptilolite zeolite (T2, T3, and T4) were higher than



(a) Dry weight of stem of *Zea mays* L. at forty five days after planting.



(b) Dry weight of leaf of *Zea mays* L. at forty five days after planting.



(c) Dry weight of root of *Zea mays* L. at forty five days after planting.

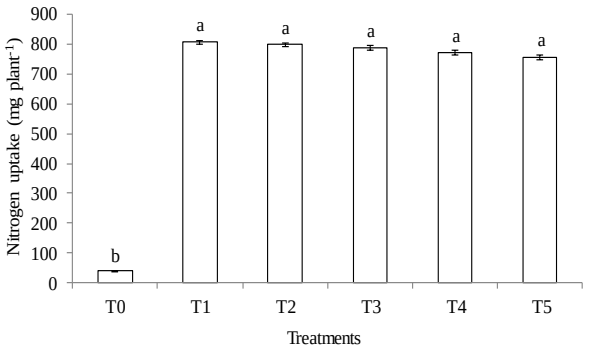
Fig. 4 Dry weight of stems, leaf, and roots of *Zea mays* L. at 45 days after planting. Bars with different letters are significantly different at by Tukey's test at $P \leq 0.05$.

inorganic fertilizer alone (Fig. 5bc). Treatment 1, T2, T3, T4, and T5 showed similar effect on the N recovery of *Zea mays* L. (Fig. 6a) but T2 significantly improved P recovery of *Zea mays* L. compared with other treatments (Figure 6b). In terms of K recovery, T2, T3, and T4 showed greater effect than the standard recommendation (T1) (Fig. 6c).

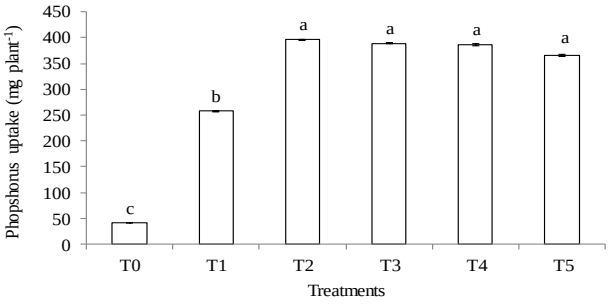
4. Discussion

4.1 Soil Nutrient Availability at Forty Five Days of Planting Maize

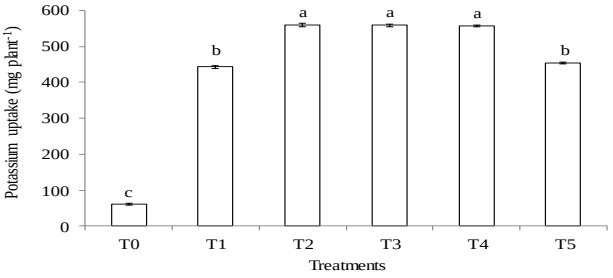
The higher soil total N in the pots with paddy husk compost and clinoptilolite zeolite (T2, T3, and T4) as indicated in Fig. 1a was partly due to the adsorption of NH_4^+ onto the negatively charged sites of the organic matter of the paddy husk compost [34] and clinoptilolite [35]. This is possible because the organic



(a) Nitrogen uptake of *Zea mays* L. at 45 days after planting



(b) Phosphorus uptake of *Zea mays* L. at 45 days after planting



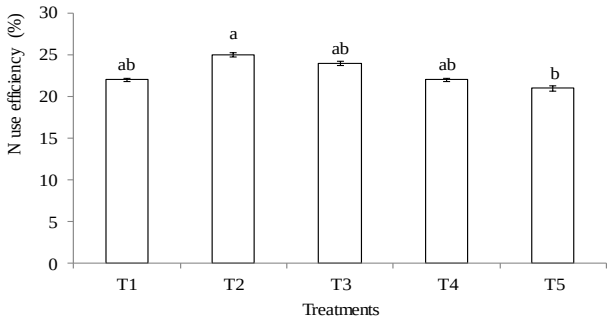
(c) Potassium uptake of *Zea mays* L. at 45 days after planting

Fig. 5 Nitrogen, phosphorus, and potassium uptake of *Zea mays* L. at 45 days after planting. Bars with different letters are significantly different at by Tukey's test at $P \leq 0.05$.

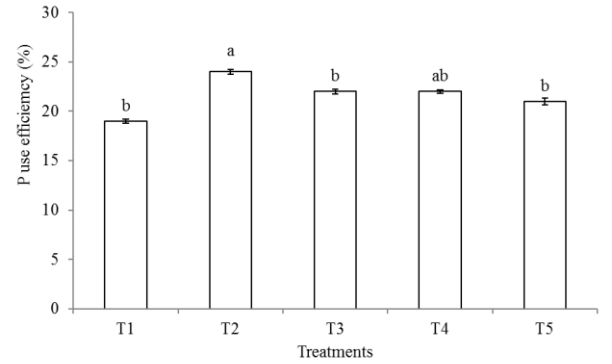
matter of the paddy husk compost used in this study was 47% (Table 2) whereas the CEC of the clinoptilolite zeolite was 100 $cmol_c\ kg^{-1}$ (Table 4). According to Siva *et al.* (1999) [36], higher total N following compost application is possible because compost reduces NH_4^+ concentration in soil solution and prevents NH_4^+ from being volatilized through NH_3 volatilization as NH_4^+ is susceptible to NH_3 loss. In terms of N loss, the retention of soil N due to paddy

husk compost application is considered as a positive interaction between compost and urea.

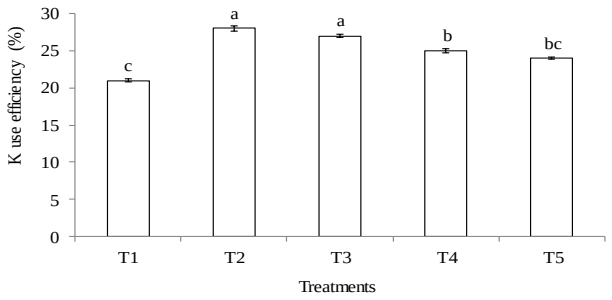
In a related study in which clinoptilolite zeolite was used in a manure-amended soil, Ramesh *et al.* (2011)



(a) Nitrogen recovery of maize plant



(b) Phosphorus recovery of maize plant



(c) Potassium recovery of maize plant

Fig. 6 Nitrogen, phosphorus, and potassium recovery of maize plant. Bars with different letters are significantly different at by Tukey's test at $P \leq 0.05$.

[37] reported that inclusion of clinoptilolite zeolite regulated N released and minimized formation of NO_3^-. Latifah *et al.* (2017) [14, 15] also demonstrated the ability of clinoptilolite zeolite to decrease N loss by trapping NH_4^+ through cation exchange. Apart from retaining NH_4^+, clinoptilolite zeolite also minimizes nitrification [35, 38]. Therefore, the lower soil total N due to T1 and T5 could be associated with the absence of clinoptilolite zeolite. At 45 days after planting, the effects of T1, T2, T3, T4, and T5 on soil exchangeable NH_4^+ and available NO_3^- were similar due to the slow release of N in the paddy husk compost (Fig. 1bc). Compared to the similar amount of inorganic N fertilizers added in T1 and T2 with the addition of paddy husk compost in T2, no significant effects on soil exchangeable NH_4^+ and available NO_3^- was because the organic N of the paddy husk compost had to be mineralized before being released into soil system.

The higher retention of soil exchangeable Ca, Mg, K, and available P in the pots with paddy husk compost and clinoptilolite was because the higher CEC of the paddy husk compost and clinoptilolite zeolite might have contributed to the improvement in soil exchangeable Ca, Mg, K, and available P. Because clinoptilolite zeolite has a high selective tendency for K^+, Ca^{2+}, and Mg^{2+}, these cations might have been adsorbed onto its cation exchange sites thus, preventing the cations from being leached [39]. This finding is similar to those of Ahmed *et al.* (2010) [40] and Junrungreang *et al.* (2002) [41] who also reported significant improvement in Ca, Mg, and K following application of clinoptilolite zeolite. The availability of P in the soil with paddy husk compost and clinoptilolite zeolite (T2, T3, T4, and T5) is ascribed to the higher contents of Ca and K of these amendments because of the release of soluble P when Ca^{2+} ions are exchanged with K^+ ions [42]. Furthermore, the content of humic acids in the paddy husk compost (Table 2) might have affected the availability of soil exchangeable Ca, Mg, and K of T2, T3, and T4 because humic acids can serve as buffer, because this process enables Ca, Mg, and K to be soluble in soils [43]. Humic acids which are major components of compost can bind cations because of the high affinity of their carboxylic acid groups for Ca^{2+}, Mg^{2+}, and K^+. In this study, the improvement in soil exchangeable Ca, Mg, K, and available P is related to the functional group of the humic acids of the paddy husk compost (Table 3) as Sahin et al. (2014) [44]

opined that functional groups of humic acids (phenolic and carboxylic) enable percolation of cations in soils and they also act as natural chelate in soils. Sahin *et al.* (2014) [44] also reported that stable complexes of humic acids with ions in soils are associated to the functional groups of humic acids because the high CEC of humic substances enables chelation of cations in soils.

The fact that the treatments with the highest paddy husk compost amended with clinoptilolite zeolite (T5) significantly increased soil pH compared with those without paddy husk compost and clinoptilolite zeolite (T0 and T1) suggests that the soil pH was influenced by the quantity of the paddy husk compost (Fig. 2). The effects of T2, T3, and T4 on soil pH (Fig. 2) could be one of the reasons for the similar effect of these treatments on total organic C and organic matter (Fig. 3) as biological activities and transformation of soil organic matter in soils are impeded when pH of soils is below 7. According to Scheffer et al. (1997) [45], low decomposition of organic matter occurs when soil pH ranges between 5.5 and 7.5 because microbial decomposition of organic matter gets impeded within this pH range.

4.2 Dry Weight and Nutrient Uptake and Recovery

The increase in the dry weight of *Zea mays* L. leaf of the soil with paddy husk compost and clinoptilolte zeolite (T4) relates to the functions of humic substances of the paddy husk compost (Fig. 4a). Humic substances temporarily hold soil exchangeable Ca, Mg, K, and available P (Table 5) after which they are released for plant uptake. The higher availability of soil total N (Fig. 1a), soil exchangeable Ca, Mg, K, and available P (Table 5) due to the paddy husk compost and clinoptilolite zeolite application (T4) also explains the increase in the dry weight of *Zea mays* L. leaf and stem compared with T1 (Fig. 4ab). Pots with paddy husk compost and clinoptilolite zeolite (T2, T3, T4, and T5) showed improved uptake of both P and K compared with T1 (Fig. 4bc) because of the high affinity of paddy husk compost and clinoptilolite zeolite for Al^{3+} and Fe^{2+}. This reaction minimizes P fixation by Al^{3+} and Fe^{2+} in highly weathered acid soils [46]. The treatments with paddy husk compost and clinoptilolite zeolite did not only supply Ca, Mg, K, and P (Table 5) but they also reduced exchangeable acidity aside from chelating exchangeable Al and exchangeable Fe ions. In a related study, the use of compost increased soil pH such that Al and Fe were fixed instead of P [47]. The higher uptake of K partly corroborates the high contents of K in the paddy husk compost and clinoptilolite zeolite (Tables 2, 4 and Fig. 5c). According to Millan et al. (2008) [48], clinoptilolite zeolite increases ion-exchange site of soils besides serving as an adsorption sites for small molecules (due to porous structure of clinoptilolite zeolite). This unique feature explains the availability of soil exchangeable K for maize plant uptake (Table 5).

The higher P and K uptake (Fig. 5) and their use efficiency in pots with paddy husk compost was because soil organic matter improves P and K availability in soils (Table 5) and this occurs through solubilization of insoluble forms of phosphate and cations (for example K^+) by organic acids produced during the decomposition of organic matter [49]. Additionally, P and K are either immobilized and used in the synthesis of new microbial tissues or mineralized and released into the soil mineral nutrient pool [50]. However, increased microbial activities may increase nutrients mineralization particularly N. Therefore, the addition of clinoptilolite zeolite in this study enable retention of N in the form of NH_4^+ and NO_3^- to prevent them from loss *via* rapid mineralization, leaching, volatilization, and denitrification [51]. The lowest P and K recovery observed in T1 (inorganic fertilizers only) was because this treatment had no paddy husk compost and clinoptilolite zeolite (Fig. 6bc).

5. Conclusions

Co-application of paddy husk compost and clinoptilolite zeolite with inorganic fertilizers

increased soil total N, available P, exchangeable Ca, Mg, and K, and P and K uptake and recovery. Soil chemical properties and productivity of *Zea mays* L. on acid soils can be improved by adopting co-application of paddy husk compost and clinoptilolite zeolite with inorganic fertilizers. The availability of soil total N, available P, exchangeable Ca, Mg, and K from different rates of urea can be enhanced if they are amended with paddy husk compost and clinoptilolite zeolite. Thus, co-application of paddy husk compost and clinoptilolite zeolite with inorganic fertilizers use in agriculture could be a potential cost effective approach for improving soil nutrients availability and crop productivity.

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Conflict of Interest

The authors have declared that no conflict of interests exist.

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Evaluation of Public Transportation of Buses in a Medium-Sized Brazilian City

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Abstract: The United Nations (UN) points out guidelines for the development of actions aimed at urban sustainability, prioritizing the use of public transport (buses). Urban mobility is universally faced with precarious quality in the provision of public transport services. The general objective of this manuscript is to evaluate the opinion of the population on the service provided by public transport companies (buses) in the city of Passo Fundo - RS (Brazil). The methodology employed aims to quantify the responses using the Likert scale, for mathematical modeling of the normal distribution calculations and obtaining the mean of the independent variables. The results obtained demonstrate the population's perception of urban public transport in the city of Passo Fundo and can assist in the elaboration of public policies and improvements in the quality of transport and road infrastructure.

Key words: urban mobility, public transportation, population opinion

1. Introduction

The United Nations considers that urban mobility on a world scale is capable of pointing out guidelines for the development of actions aimed at the sustainability of cities [1]. The development plans can promote sustainable urban mobility by determining non-motorized means of displacement and no longer the use of automobiles [1].

However, urban mobility in a universal way comes across with the absence of quality in public transport, according to Ref. [2], which can influence the use of the individual motor vehicle. The public tax incentives for the automobile industries, in turn discourage the use of public transportation. Consequently, for D. A. C. Álvarez [3], the economy revolves around trade in private vehicles discouraging the use of public transportation of urban aimed at the by users.

The automobile to R. S. Scaringella [4], assumes negative role in relation to its quantitative growth in the different cities of the world. However, the cities can't be thought without the existence of paths that allow the accessibility motor vehicles private [5].

According to data from the International Organization of Automobile Manufacturers in 2005 had 892,028 million vehicles already in 2016 accounted for 1,282,270 billion vehicles, thus representing an increase of more than 143% in the world fleet [6]. In this relationship, projections made by the United Nations (UN) identified and estimated the increase of the motor vehicle fleet from 1.3 billion in 2017 to 2 billion by 2050 [7].

This constant increase in the vehicles number can cause problems systems in mobility and disability

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systems in urban traffic systems increasing traffic jam [8, 9]. One of the possible solutions of this domain is related to the researches by F. Villaça [9] and Roberto et al. [10] would be an allocation of investments aimed at urban mobility to carry out studies that would allow the understanding of the road economy in relation to urban design and could stimulate the use of collective support (buses).

When considering a road network, it is worth highlighting the presence of paths that allow the diversification of the modes of transportation of people in relation to the forms of access provided by the urban design [9]. This relationship, suggests that, it is necessary the access and locomotion of the citizens of the environments constructed in an egalitarian way [11].

Starting from this assumption, the studies of [4, 9, 10, 12, 13] reinforce that the project mobility for the use of public transport, when encouraged enables the advantages of traffic, as reduce as well traveling time, polluting gases and traffic accidents. Another factor, to be applied in urban projects focused on transport mobility, is a security requirement. Another factor, to be applied in urban, is a security requirement criminal inside buses and near bus stops tend to compromise the quality of public transport in cities [14].

Therefore, public transportation is seen as the main tool for inclusion and accessibility of citizens in different parts of the city. However, it is incumbent on the public bodies to provide incentives for the use of urban public transport as well as a better quality of services, which can improve the mobility of people in cities [11].

2. Material and Methods

The city of Passo Fundo, located in the southern region of Brazil and according to the last census conducted in 2010, concentrates 184,826 thousand inhabitants, with a population density of 235.92 hab./km², being the 146th most populous city of the country, of the state, besides being the city with the largest population in the microregion of the production, extending with territorial area of 783,421 km², being divided in 36 neighbourhoods in the urban zone [15].

The population of Passo Fundo in 2018, where it was verified 201,767 thousand inhabitants, that is, in seven years the population of the city rose by 8.39%, with 16,941 new inhabitants in the city. The period from 2010 to 2018 is considered as the temporal cut of this article, since it is based on verified and reliable data provided by IBGE regarding population and density [15].

From this, an applied methodology is qualitative in terms of experimental study. The first step consists in analysing the data diagnoses to design models for the years 2010 to 2018.

After the identification of the number of vehicles and vehicles in circulation, a space analysis was carried out to measure the integration of the bus route in the city. The application data of the forms Relative (RA) asymmetry and relative real asymmetry (RRA), Eqs. (1) and (2) respectively. Will result in a spatial representation in chromatic scale, in which the higher values of integration are represented by warmer colors (red, orange, amber), while lower values representing the lines with a greater degree of segregation are presented by cold colors (green, cyan and blue) [16].

Eq. (1) Relative asymmetry

$$RA = 2\,(dmean-1)/k-2 \quad (1)$$

Where: dmean = is the average depth of all nodes in the graph; k = the total number of nodes in the graph; RA - Relative Asymmetry is equal to twice the average depth, minus 1, divided by 2

Eq. (2) Asymmetry and relative real asymmetry

$$RRA=\left(\frac{Ra}{Dk}\right) \quad (2)$$

where: RA = Relative Asymmetry; Dk = constant; RRA - Relative Real Asymmetry (Global integration) compares systems of different sizes, dividing the relative asymmetry by a D value stipulated for that number of spaces [16].

The second stage is characterized by the application

of the research tools, being of random order for the respondents who waited in the bus stops, in each of the functional centers of the studied city. The applied research instruments aim to make an individual analysis on the opinion of the public transport user population of the city of Passo Fundo/RS.

For the elaboration of this article, the answers of the research instruments were classified into three groups of analyses. The first group refers to: quality of the stops (PC), signalling (SNPC), cleaning and lighting (ILPC), security (SPC) and the second group to the calculation of urban collectives (EPDES), the number of collectives (CUH), number of urban collectives (EPNE), time of service (CUH), number of groups (EPM), (HMEM), hours of major movement in the streets (HMEM), the provision of the service on weekends (AFS), number of buses at weekends (QNTF), in turn, the third group has as questions to identify the opinion within the bus about the safety inside the bus (STP), temperature (TTP), maintenance (MTP), noise (RTP).

The quantification of respondents' opinion poll tools on the Likert scale (1-5), which corresponds to 1 a "very bad" and 5 to "excellent" characterization. And as a research tool use of SPSS (Statistical Package for Social Sciences) and JASP, and later correlated with the other variables. To obtain the values related to the sample size of the research instrument, use the sample test for Eq. (3), developed by E. Maricato [5] with sampling error of 5% and the reliability index of 90%.

Eq. (3) Sample reliability index

$$n = \frac{N.Z^2.p.(1-p)}{Z^2.p.(1-p) + e^2.(N-1)} \quad (3)$$

where: n - calculated sample, N – population, Z - standardized normal variable associated with the confidence level, p - true event probability, and - sample error

The definition of sample size was based on population estimates for the year 2018 [18]. Where, Passo Fundo (RS) has 201,767 inhabitants. The data submitted to the calculation formula resulted in the sample of 271 research instruments (questionnaires) for city [17].

After the definition of the reliability index of the questionnaire, the Cronbach Alpha technique, which was presented in 1951, by Lee Cronbach, will be applied, and the alpha coefficient is estimated by the average correlation of the answers of each question. Thus, the coefficient Alpha is calculated by the variance of the individual items of covariance by means of Eq. (4) [19].

Eq. (4): Questionnaire reliability index

$$\alpha = \left(\frac{k}{k-1}\right) x \left(-1 \frac{\sum_{j=1}^{k} s_{i^2}}{st^2}\right) \quad (4)$$

k: corresponds to the number of items in the questionnaire; *s²i:* corresponds to the variance of each item; *s²t:* corresponds to the total variance of the questionnaire, being the sum of all variances. The Alpha coefficient ranges from 0 to 1.

The classification according to Table 1 the reliability of the alpha coefficient, which is considered satisfactory when the research instrument maintains the alpha value > 0.7 [19].

The validate the reliability of the questionnaire is measured by the average correlation of the questions, from the variance of the individual variables and by the sum of all the items of the questionnaire that use the same Likert measurement scale [20].

For the coefficients, we considered k = 16 which represents the sum of the questions with the same Likert scale, s²i = 13,570 which represents the correlation of the answers of the same variables and s²t = 60,756 represents the variance resulting in a reliability index of the questionnaire presented by the alpha coefficient of 0.82 which represents a reliability level of the high questionnaire Table 2 [20].

Thus, to evaluate the relations of the answers of the research instruments will be executed the calculations

Table 1 Reliability of the alpha coefficient.

	Reliability				
	Very low	Low	Moderate	High	Very high
Alpha	< 0.3	> 0.3	< 0.6	> 0.75	> 0.9

Table 2 Reliability of the alpha coefficient.

Coefficient				
	K	S^2i	S^2t	Alpha
Result	17	13,570	60,756	0.82

of normal distribution or commonly denominated Gaussian distribution. The Eq. (3), which allows to study the probabilistically the average of the independent variables, according to their standard deviation, variance and average, evaluating the independent aggregate behaviour and similarities obtained through the sample results [21].

Eq. (5): Normal distribution

$$n(x;\mu,\sigma) = \frac{1}{\sqrt{2\pi\sigma}} e^{\frac{1}{2\sigma^2}(x-\mu)^2} \quad (5)$$

where: n: value of the normal distribution; μ: mean σ: standard deviation; π: Pi, 3.14 ...; e: Constant of Euler, 2.71 ...; x: density of the random variable x; σ^2: variance

3. Results and Discussion

3.1 Passo Fundo Urban Transport

The Passo Fundo city had its historical conformation as a land of passage of the tropeiros that took cattle to São Paulo, the axis that today is known as Brazil Avenue, that railroad that crossed parallel, conformed the urban organization [24].

The Av. President Vargas and Av. Rio Grande are considered as structuring axes of the municipality with trade and services being possible to connects north and south of the city, along with the sub centers along these avenues [22]. Due to this urban conformation these roads concentrate a large flow of vehicles, and more and more vehicles are in circulation as represented in Table 3, the fleet of automobiles of Passo Fundo grew 40% of the period from 2010 to 2018 this gradual increase ends up by overcrowding the avenues causing congestion and consequently more slow circulation of the vehicles [15].

These problems of the use of private vehicles are multidimensional and are related to the exaggerated occupation of the space for the transportation of

Table 3 Fleet of vehicles in Passo Fundo.

Modal	2010	2018	Increase
	un.	un.	%
Car	57.894	78.827	36
Motorcycle, and moped	15.496	19.784	27
Truck and Tractor Truck	3.940	4.961	25
Utilities, Truck & Vans	9.188	17.903	94
Bus and Micro-bus	529	651	23
Others	2.371	3.613	52
Total	89.418	125.739	40%

passengers, congestion, delays, air pollution and noise resulting from these congestions, the impacts resulting from the transportation systems are aspects that affect the sustainable development of cities [23, 24].

The sustainability of urban transport is associated with urban mobility according to economic, social and environmental standards and practices. It is an extension of the axes of urban sustainability, with the challenges that all cities face in terms of the territorial misalignments between the concentration of services, relation to the location of the residences. Thus, mobility tends to be based on more polluting modes of transport (motor vehicles) to ensure the functionality of this territorial dispersion as far as land uses are concerned [25].

Promoting the collective transportation system is one of the main ways to promote sustainable urban mobility, since poorly planned urban sprawl driven using individual motorized vehicles ends up distancing people from services and opportunities to live with quality of life in cities [26].

The collective transport of the city of Passo Fundo, is administered by the Municipal Transportation Department (STSG), which are three companies that participate in the concession since service. The service to the population is carried out by 146 bus, the majority of the service carried out by the company private Coleurb which counts 98 bus in circulation and another 12 bus for substitution purposes, followed by the company Codepas which holds 23 bus and 20 in

circulation and put an end to the company Transpasso, which has 13 bus with 8 in circulation Table 4 [27].

The city of Passo Fundo has more than 80 routes with 41 operating lines without alterations between the trajectories and routes, having as main sense the increase of the mileage and the costs that impact the passage value. Of these 38 bus lines are integrated as the lines and the routes causing an overlap of lines and decreasing the central waiting time [26]. However, the frequency of bus traffic in peripheral areas tends to be smaller, forcing the population to look for other modes of displacement.

This fact can be verified with application of spatial syntax Fig. 1, from several offer lines located in the center of the city causing a more quality to access provide services in this area by the overlapping larger. However, this route, there is a greater congestion of cars and buses due to the lack of an exclusive route to the bus.

Table 4 Fleet of urban collectives of Passo Fundo.

Companies	Organization	2018	In circulation	Increase
		un.	un.	%
Coleurb	Private	110	98	89
Codepas	Public	23	20	86
Transpasso	Private	13	8	61

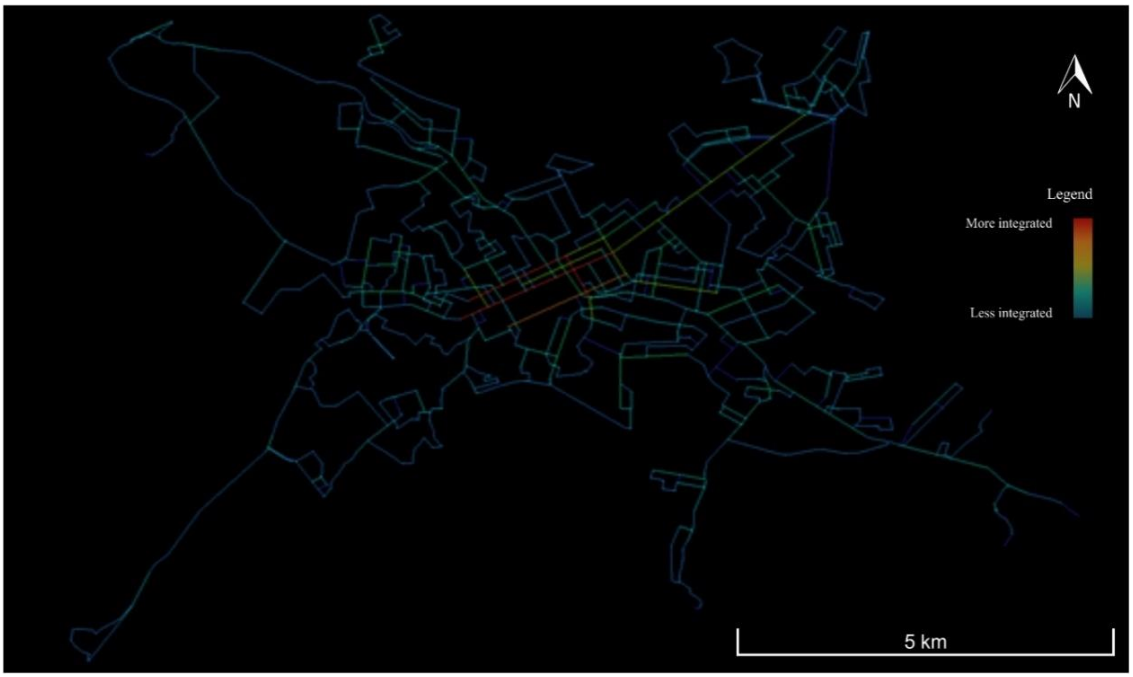

Fig. 1 Spatial syntax of the bus lines of Passo Fundo.

Already in the peripheral areas represented by blue color it is the lines not being with a degree of integration in relation to the others, favoring a more fluid attendance, with greater speed and frequency of urban groups smaller. But with less frequency and constant delays, which favors the preference for the use of other transport modes being one of the main discourages of the use of the public transport service [13].

3.2 Evaluation of the Population Regarding the Urban Transport of Passo Fundo/RS

In the second stage, we sought to verify the population's opinion on public transport. The respondents evaluated the bus stops as signaling the cleanliness security and the ease in boarding of people with special needs.

Thus, it was found from the answers that question PC obtained an average of 2.68 from the opinion of the respondents with a standard deviation of 0.89, whereas in relation to the SNPC an average of 2.58 was found, with a standard deviation of 0.88, the question about ILPC resulted in an average of 2.4 with a standard deviation of 0.92, finally SPC obtained the highest level of reprobation with an average of 2.21 and a standard deviation of 0.94.

The questionnaires' application revealed the conditions of bus stops Fig. 2. Thus, through the analysis of the Gaussian curve, it was found that the average of respondents' answers was 2.47, with a standard deviation of 0.92, thus considering that the conditions offered by urban bus stops were evaluated as bad by the population that uses urban public transport.

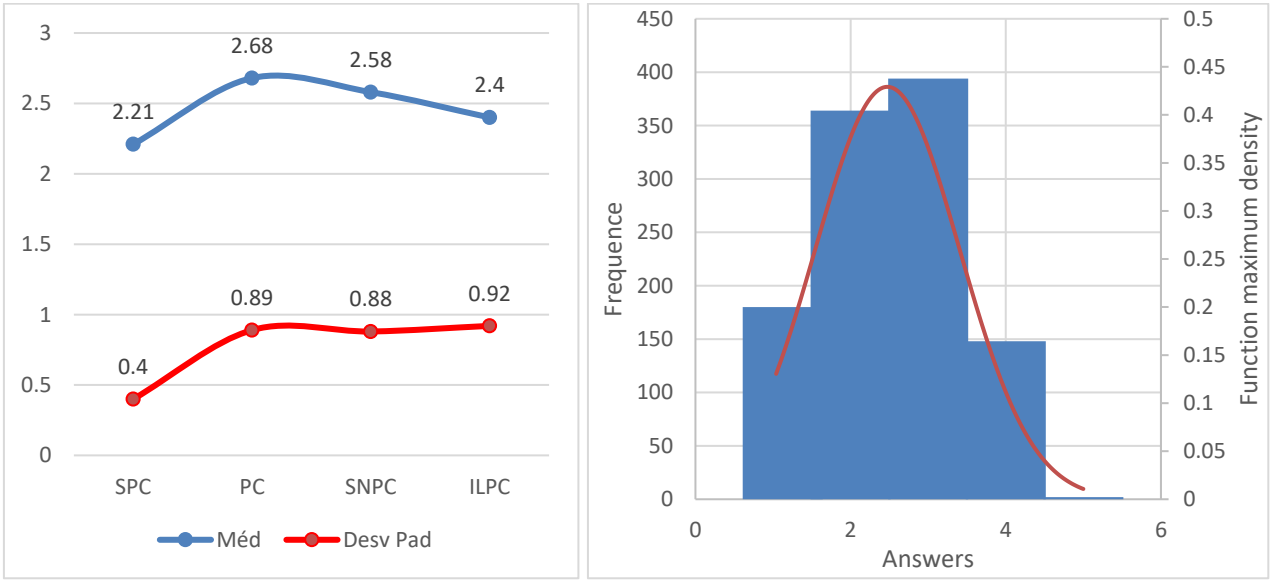

Fig. 2 Gauss' curve regarding the conditions of urban collective stops.

In this relation it can be affirmed based on the answer of the interviewees that the stops of the urban collectives are mainly problems in signalization and illumination. These directly interfere in the perception of safety of the stops what was verified by the respondents.

In this relation it can be affirmed based on the answer of the interviewees that the stops of the urban collectives are mainly problems in signalization and illumination. These directly interfere in the perception of safety of the stops what was verified by the respondents.

Stops for the embarkation of the passengers in a predefined line, is a key element of the attendance performance to the population that uses the urban collectives. So, the revitalization constitutes a fundamental factor of these urban facilities can attract more users giving special attention to location, spacing and performance guidelines, lighting, safety, and signaling [28].

The second group of questions made it possible to understand the group of questions about urban bus movements. When accounting for the results of the application, the following results were obtained in relation to the EPNE, obtained a mean of 2.63 of the opinion of the respondents with a standard deviation of 0.89, while in relation to the CUH an average of 2.7 was found with deviation standard deviation of 0.89, the question on the QCU, resulted in an average of 3.02 with standard deviation of 0.81, resulted in a mean of 2.95 with a standard deviation of 0.98, relative to HMEM, it was found that the mean was 2.87 and the standard deviation was 0.84, while the AFS question resulted in an average of 2.63 with a standard deviation

of 0.98, thus, when assessing QNTF, the mean 2.97 with a standard deviation of 0.84, RDES obtained the highest level of approval in this group with an average of 3.23 and a standard deviation of 0.81.

And through Gauss' analysis, it was verified that the average of respondents' answers was 2.88, with a standard deviation of 0.94, Fig. 3, the results obtained showed a deficiency in the provision of public transport services.

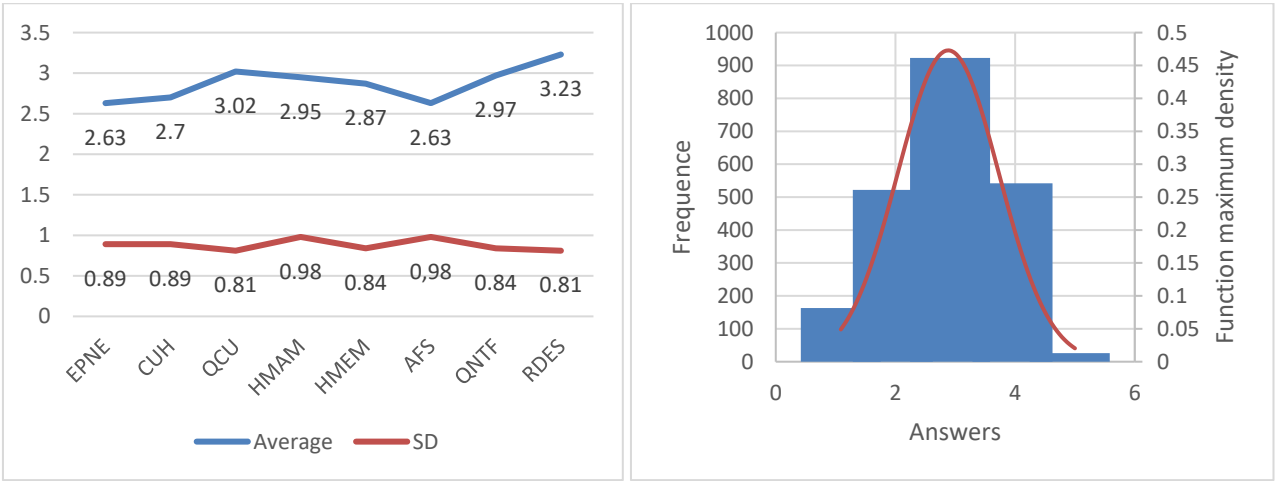

Fig. 3 Gauss' curve regarding the displacement of public urban transport.

This factor is verified more frequently in areas of difficult access or with average of low-income areas. In that urban public transport system often becomes almost impossible a shift with a speed due to the narrow or winding streets, resulting in a shift with longer delay stopping points [29].

To meet this demand that has difficulties of accessibility by modal, small vehicles are intended to connect through local lines to the community the lines closest to the regular interconnections and diametral transport lines of the system being this a complementary service that extends the service to lower cost [29].

It should be remembered that urban collective transport along their trajectory have not received adequate and preferential treatment in urban roads, being often oppressed for the non-interference of the private vehicles circulation, the dispute for the road space ends up making the traffic slower and consequently the system of transportation less reliable and satisfactory to users [30].

The intense traffic of vehicles and the dispute over the road space, other factors also have a direct influence on the collective displacement time, such as the speed of movement, pavement conditions and characteristics of the roads, the distance between stops of collectives [28]. Describes that the waiting time as the interval between the embarkation in the urban collectives, the lack of information about the itineraries and schedules are factors of disapproval of the use of public transport, which lose space in front of the other modes of transportation [31].

The third group of analyses verified the information collected regarding urban buses. Analysed from the respondents' answers that STP counted an average 2.84 in relation to the respondents' opinion, with a standard deviation of 0.83, while in relation to the TTP the average value was equal to 2, 65 with a standard deviation of 0.86, the MTP resulted in an average 2.76 with a standard deviation of 0.90. The accounting of responses demonstrated the mean of the responses was 2.91 with a standard deviation of 0.87. In this way, questionnaires' application revealed the characteristics of urban groups Fig. 4. Thus, through the analysis of the Gaussian curve, it was found that the average of respondents was 2.68, with a standard deviation of 0.87.

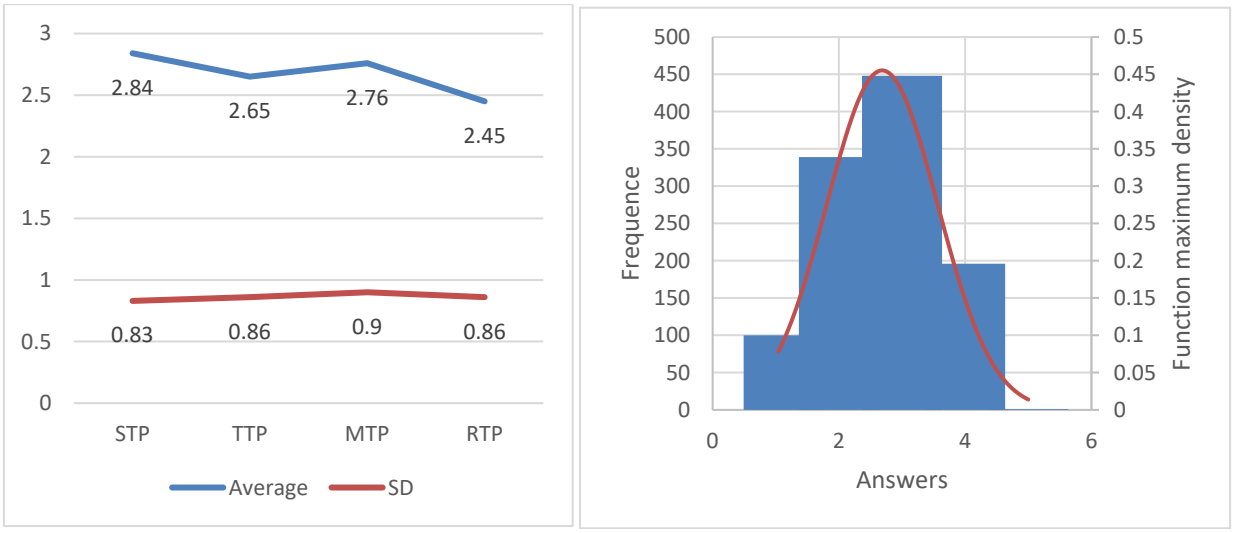

Fig. 4 Gauss' curve regarding the displacement of public urban transport.

According to the application of the research instruments, the perceptions of the respondents regarding the safety of the urban collectives presented a low approval of the system. This important factor tends to disadvantage the use of modal by the population [13, 14].

Thus, it is necessary to apply public policies that aim at the adequacy of these collectives according to the needs. These questionnaires point to some of the main weaknesses in the provision of public services in the city of Passo Fundo/RS.

Finally, it is the administrator of the services together with government agencies, to provide greater efficiency, comfort and safety to users, since urban public transportation is an important mechanism for inclusion of citizens, favouring access to different parts of the city by encouraging the sustainable mobility [10].

4. Conclusion

From the results collected in the interviews, it is noted that the population of Passo Fundo/RS considers public transport to be bad, thus causing in the desistence by the use and preference for the private vehicle. There is a need for more incentives and public policies and increase investment in public transport in order to improve the quality not only of urban collectives, but also of bus stops, providing people with adequate lighting and especially security.

The overload of the roads, which causes delays in the urban collectives and the existence of a non-integrated overlapping system of the bus routes, results in a need for requalification in order to apply the concept of an integrated transport network, providing a better quality of the displacements for the population. However, the reorganization of the lines becomes unsustainable in that it is planned to serve small routes for small groups of users generating an overloading of the road axles.

In this way the modifications of the operations of the diametrical lines (neighborhood connection with the central area of the city) and the radial ones (neighborhood-center) must create lines between neighborhoods which connect more of a neighborhood passing without passing through the central part avoid road congestion.

The reclassification of urban furniture from urban bus stops is also of paramount importance for users' preference in using the modal. This should include new banks, shelters, itinerary information with schedules, adequate lighting for the stops and the system of monitoring by cameras that would increase the safety of users.

Finally, public transport is one of the main agents for the sustainable development of cities with more

efficient displacements and a better utilization of the road network favoring the user boarding facilities and transport safety. However, more resources should be invested in upgrading the fleet and road infrastructure, coupled with incentives to support the use of public transport over other modes. Thus, attracting new users and more frequent use of public transport instead of their private vehicles.

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Effect of Fertilization and Pruning on Inulin Levels of Yam Bean

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Abstract: Market demand for inulin as functional food tends to increase every year. Tuber of yam bean was one source of inulin, potential to be developed. Research that aims to determine the effect of fertilization and pruning on tuber yam inulin levels has been carried out in Duku, Padang Pariaman, West Sumatra, Indonesia and the Agricultural Product Technology Laboratory of Andalas University from January to July 2019. Using experimental methods, environmental design were Split Plot Design 4×4 with 5 replications. The main plot is pruning: without pruning, shoot pruning, flower pruning, shoot and flowers pruning. The subplots were NPK fertilizer (15:15:15) doses of 100,125,150 and 175 kg ha-1, the levels of inulin were tested by the Cysteine-Carbazole method. Data were processed using Statistics 8, LSD test continued at a level of 5%. The results showed that applying fertilizer with different doses combined with different pruning would produce tubers with different levels of inulin. The tuber inulin content has interval 9.36-24.39% with a degree of polymerization interval of 8.50-28.75. The highest levels of inulin were obtained by combining a 125 kg ha-1 NPK fertilizer dose with shoot pruning.

Key words: tubers, fertilizing, pruning, inulin, functional food

1. Introduction

Yam bean ((*Pachyrhizus erosus* L. Urban) is a plant introduction that can grow well in Indonesia. Tuber is considered as fruit is the main product of yam bean that has been used in everyday life, especially for fresh consumption and food stuffs, potential yam bean developed in the field of pharmacology and industry in the future. Nevertheless, the current popularity of yam bean is still lacking, because it has to compete with other commodities that are considered higher quality, even less the tendency of people to consume imported commodities from abroad, so the IPGRI (*International Plant Genetic resources Institute*) categorizes the Yam Bean as a neglected and unexploited plant [1]. Therefore, it is necessary to study the research to improve the quality of yam bean.

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Advances in bioscience stated that the diet modulates various bodily functions. Diets can maintain health and reduce the risk of some diseases, so that the concept of functional food develops rapidly. Inulin is one of the functional foodstuffs [2].

Inulin is very widely used in industrial, commercial scale Inulin manufactured from chicory plant, So the last few decades chicory inulin production in Western Europe has risen from 1,000 to 100,000 per year [3].Indonesia has not been able to produce inulin industrily, because chicory does not grow here, so the need for both inulin industry and research 100% is still imported from some countries, such as Belgium, Australia, China and India (Indonesian Institute of Sciences, 2010). Therefore production of inulin from local raw materials very need to be developed.

Nurrohman et al. (2010) [4] says that the sweetness of the yam bean tuber is due to inulin content. Supported by the results of research [5] which obtained

that the extract of yam bean tuber water contains inulin at 24.331%. The levels of inulin yam bean tubers are influenced by various factors, the height of planting, varieties, harvest age and plant growth conditions.

Plant growth conditions are closely related to the availability of nutrients absorbed by plants. Nitrogen (N), Phospor (P) and potassium (K) are essential elements that should always be available. Growth and development of plants. In order to have enough crop needs be given the addition of fertilizer. Zanklan (2003) [6] said that the production of yam bean can also be improved by developing the technique of leaf tip pruning and reproductive pruning (flower and pod pruning). Because pruning can reduce competition between sinks in plants, with pruning is expected to occur photosynthesis to the tuber, so that the tuber results will increase. This research aims to see the influence of fertilization and pruning on the levels of yam beans inulin.

2. Research Methode

2.1 Planting

Yam Bean is planted in Duku's community field, Padang Pariaman Regency, West Sumatera. Laboratory observation was conducted at Laboratory of agricultural technology, Andalas University from January to July 2019.Using experimental methods and Environmental design Split Plot 4×4 with 10 repeats. The main plot is the NPK (15:15:15) brand of Ponska (100, 125, 150 and 175 kg ha^{-1}). Half the dose gave when the plant is 15 days old and another half the dose when the plant is 60 days. Plot is pruning treatment that is without trimming, crop the tip (at the age of 45 days), crop the flower (when the plant begins to bloom), crop the tip and flowers (flowers cropped when the plant begins to bloom and the tip cropped when the plant aged 105 days).

2.2 Observation

2.2.1 Measurement of Wet Weight Tuber

Tuber is harvested when the plant is 135 days. The tuber is separated from the stem and the root ends, then washed clean, wind drying and weighed in the wet weight.

2.2.2 Testing Inulin Levels with the Method of Cysteine Karbazol [7]

(1) Inulin Flour Extraction

The extraction of inulin flour was done based on a method done by Susdiana (1997). Weighing first before processing done. Then cleaned from the dirt attached to the skin and then shredded using a grater machine. The result is added to the water by comparing water and the grater result 2:1. The mixture is then heated to a temperature of 80-90°C for 30 minutes. The results are cooled and filtered to be taken the filtrate. The volume of Filtrate measured and added absolute ethanol as much as 40% filtrate. The solution is stored in a freezer temperature -18°C for 18 hours until the deposits are obtained. Deposits are dried with an oven to a constant weight. The obtained result is mashed into inulin flour.

(2) Testing Inulin Levels

0.1 grams of inulin flour was dissolved in 10 ml aquades. 1 ml samples added 0.2 ml cysteine 1.5%, then added 6 ml H_2SO_4 70% and shaken. The mixture was then added 0.2 ml of the 0.12% of carbazol in ethanol solution. Then heated at 60°C for 10 minutes, then cooled and measured the inverse rate using a spectrophotometer with a wavelength of 560 nm. Standard curves made using standard Inulin (Inulin cichory) with a range of 20, 40, 60, and 80 ppm.

2.2.3 Total Sugar Testing of the Phenol Method [8]

For a standard curve as much as 2 ml of standard fructose solution which each was pipetted and inserted into the test tube, then added 0.5 ml of phenol solution 5%, then shaken. Added 2.5 ml H_2SO_4 concentrated. The absorbance was measured with a spectrophotometer at a wavelength of 490 nm. The total measurement of sample sugar must be clear liquid. Samples were diluted with distilled water. The sample determination was done like on a standard curve

creation, then prescribed total carbohydrate or total sugar samples.

2.2.4 Testing of the Reducing Sugar content of DNS method [9]

Samples were diluted until scalable at a range of 0.2 to 0.9 absorbance at a wavelength of 550 nm. A total of 1 ml of the sample was inserted into the test tube, then add 3 ml of the DNS reagent. Heated in boiling water for 5 minutes, allowed to cool in room temperature. And read its absorption. the form used is distilled water. The standard curve is made using a standard fructose solution, a range of 0-300 mg/L.

2.2.5 Degree of polymerization [8]

The value of polymerization degree was obtained by dividing the total value of sugar on the value of reducing sugar.

2.3 Data Analysis

To see the effect of treatment, data was processed with Program statistics 8. If there is a difference in treatment of the outcome, the LSD 5% level advance test then done.

3. Results and Discussion

Fertilization is the provision of additional nutrients on the soil either directly or indirectly that aims to improve soil conditions, improve soil fertility, provide nutrients to plants, and improve the quality and quantity of crop yield. NPK Fertilizer (15:15:15) Phonska is one of the compound fertilizer subsidized by the Government so that the price is cheaper and affordable by farmers. Consists of several macro nutrients, namely nitrogen (N), phosphor (P), potassium (K). The advantage of using this fertilizer is the same nutrient content as single fertilizer, the use of compound fertilizer is very practical, low transport costs and save storage space.

NPK Fertilizer is important for plant growth and development and crop yields. *N* nutrients absorbed by plants in the form of ammonium ions (NH^{4+}) or nitric ions (NO^{3-}), are the building materials of amino acids/proteins, enzymes, nucleic acids, nucleoproteins, and alkaloids. *N* deficiency will limit cell cleavage and magnification.

The *P* nutrient is taken plants from within the soil in the form of H_2PO_4 ions, serving as important structural components such as ADP, ATP, NAD, NADPH, and components of the genetic information system, namely DNA and RNA. The nutrients *K* is absorbed by plants from the soil in the form of K+ ions, functioning as activators of 46 kinds of enzymes, plays a role in the process of photosynthesis, improvement of LAI (leaf area index), and increase photosynthesis of translocation from source to recipient. Potassium also acts as a balancing water balance in cells, cell Turgor, responsible for the production and transportation of sugar, increasing crop tolerance to drought or cold stress as well as pest and disease attacks. And will improve the harvest from both aspects of color, taste and the power of the bait.

To nurture crops, pruning is a stage that can't be missed. Pruning is the act of eliminating unwanted plant parts in existence. In the cultivation of yam bean tuber producer is usually done reproductive pruning that removes reproductive organs such as flowers and pods.The pruning tips aim to limit the length of the stem and eliminate the apical dominancy so as to stimulate the lateral growth.From the treatment of pruning and fertilization given, the photosynthesis results can accumulate maximum on the tuber.

Table 1 is seen that the interaction of fertilizer and pruning has a value of P = 0.9489, greater than at 0.05 (95% confidence interval). It means the treatment of dose of fertilizers combined with different pruning gives a no different effect to the wet weight of the tuber. But the treatment of different doses of fertilizer or pruning in a single, has a value of P respectively 0.0002 and 0.0000, meaning that the treatment of fertilizer dose or different pruning treatment by a single gives a different effect to the wet weight of the Yam Bean tuber.

Table 1 Effect of NPK fertilizer dose and pruning to wet-heavy tuber Yam Bean (%).

Fertilizer Dose (kg ha^{-1})	Pruning									
	TP		PP		PB		PPPB		Average	
100	82.79	f	**84.29**	**f**	193.69	cdef	292.49	bcd	163.32	C
125	182.39	cdef	153.79	ef	265.39	bcde	308.06	bc	227.41	BC
150	159.59	ef	166.39	def	305.19	bcd	305.19	bc	231.17	B
175	194.99	cdef	242.79	bcde	368.06	ab	**459.49**	**a**	**316.39**	**A**
Rata-rata	154.94	B	161.82	B	280.22	A	**341.31**	**A**		

Value P: Fertilizer Dose = 0.0002; Pruning = 0.0000; Fertilizer Dose * Pruning = 0.9489

Description: The numbers in the columns and lines followed by the same lower case indicate the effect of interactions with the dose of fertilizer and pruning which do not differ in the LSD test with a 95% confidence interval. The numbers in the column/row followed by the same capitalization indicate the single influence of the dose of fertilizer or pruning which do not differ in the LSD test with a 95% confidence interval. TP = No Pruning, PP = Tips pruning, PB = Flower Pruning, PPPB = Tips Pruning and flower, P = Significance Value, * = interaction.

The combination of treatment of dose of fertilizer and different pruning obtained the tuber that has wet weight with a range of 82.79-459.49 gram. The effect of optimum interaction to increase the wet weight of the tuber is at a dose of 175 kg ha^{-1} fertilizer combined with the treatment of crop and flower trimming. The optimal fertilizer dose generally applies to increase the wet weight of the tuber is 175 kg ha^{-1}. And the generally prevailing optimum pruning treatment is the pruning of the tips and flowers.

Increase the dose of fertilizer is directly proportional to the increase of wet weight of the tuber, where the greater the dose of fertiliser given, then the greater the fresh weight of tuber. It means NPK fertilizer 175 kgha^{-1} is a proper dose to increase the fresh weight of the tuber.

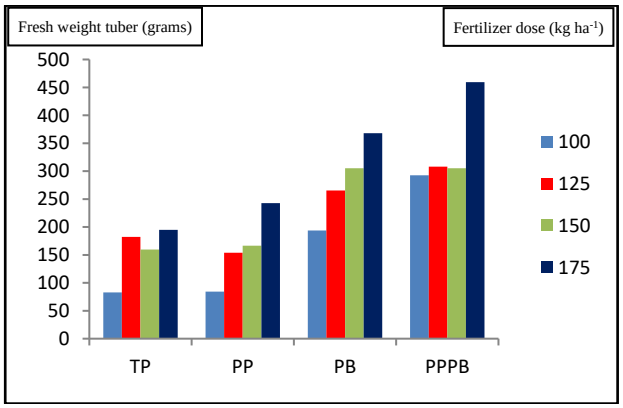

Fig. 1 Graph influence of Dose NPK fertilizer and pruning on wet weight of Yam Beans tuber.

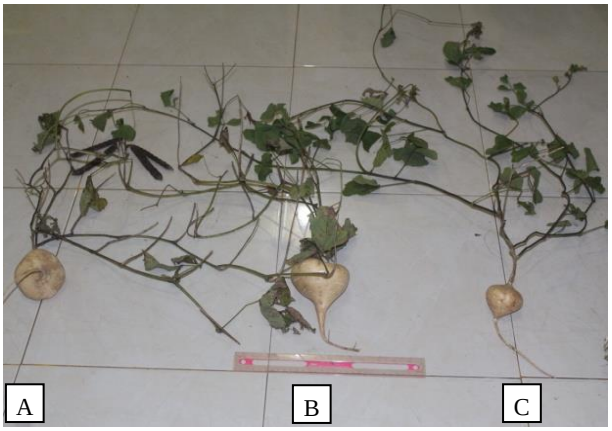

Fig. 2 Yam beans fresh harvest:A = PP, B = PPPB, C = TP.

Inulin is a group of natural polysaccharides found in yam bean tuber, which are used as energy reserves and regulate crop resistance. Inulin is composed of fructose units and usually has a glucose terminal that joins the β Glycoprint bonds (21).

Table 2 seen that the interaction between the dose of fertilizer and pruning has a value of P = 0.0003, meaning that the interaction between the fertilizer dose and different pruning gives different effects to inulin levels in the 95% confidence interval. Similarly, with a single giving, the treatment fertilizer dose or pruning has a value of P respectively 0.0000 and 0.0135, meaning that the treatment fertilizer dose or different pruning treatment gives different influence on the level of inulin yam bean tuber.

Table 2 Effect of NPK fertilizer dose and pruning on Yam bean tuber Inulin levels (%).

Fertilizer dose	Pruning									
(kg ha^{-1})	TP		PP		PB		PPPB		Average	
100	16.86	bcde	12.42	efghi	15.54	defg	20.49	abc	16.33	B
125	15.72	cdefg	24.39	a	14.69	efgh	21.09	ab	18.97	A
150	9.36	i	19.90	abcd	16.37	bcdef	13.66	efghi	14.82	B
175	11.26	ghi	11.89	fghi	11.83	fghi	10.13	hi	11.28	C
average	**13.30**	**C**	**17.15**	**A**	**14.61**	**BC**	16.34	AB		

The value of P fertilizer dose = 0.0000; Pruning = 0.0135; Fertilizer * Pruning = 0.0003

Description: The numbers in the columns and lines followed by the same lower case indicate the effect of interactions with the dose of fertilizer and pruning which do not differ in the LSD test with a 95% confidence interval. The numbers in the column/row followed by the same capitalization indicate the single influence of the dose of fertilizer or prunig which do not differ in the LSD test with a 95% confidence interval. TP = no pruning, PP = Tip Pruning, PB = Flower pruning, PPPB = Tip Pruning and flower, P = significance value, * = interaction

From the interaction of the dose of fertilizer and pruning treatment, the tuber is obtained with inulin levels of 9.36-24.39%. The effect of interaction of fertilizer dose and optimum pruning to increase the level of inulin yam bean tuber is a combination of fertilizer dose of 125 kg ha^{-1} and the pruning of tips. The optimum fertilizer dose on the treatment without pruning is 100, in kg ha^{-1} tip pruning treatment is 125 kg ha^{-1}, on the treatment of flower pruning is 150 kg ha^{-1} while the treatment of tips and flowers pruning is 125 kg ha^{-1}.

In single, optimum NPK fertilizer dose generally to increase inulin levels is 125 kg ha^{-1}. While the treatment of optimum pruning is the effect of tips pruning.

Yam bean has a semideterminate type of growth, which is a type of plant whose vegetative growth continues even though it has entered the generative phase (flowering), a new vegetative yam bean growth will stop after the formation of flag leaves (aged 100-105 days of planting).

Yam bean generative growth phases along with the formation phase of the tuber (tuberization), at this time there is photosintat scramble. In research obtained, the small dose of fertilizer will extend the time of filling tuber, so that the maturity of tuber is also slow. While the higher the dose of fertilizer gave accompanied by pruning, it will accelerate the process of maturation of the tuber (visible with the start of yellow and dried leaves).

So the higher the dose of fertilizer will minimize levels of tuber inulin. Rutherford et al. (1971) in Doorell et al. (1977) says that invertase activity increases during tuber replenishment and decreases at the end of tuber maturation, followed by increased hydrolase activity. This can result in inulin degradation and the occurrence of a lower molecular weight (polymerization degree) of Polyfruthane.

The degree of polymerization is derived from the total percentage distribution of sugar with reducing sugar. In Table 3, it appears that the interaction treatment of fertilizer dose and pruning has a value P = 0,0000, smaller than 0.05 (confidence Interval 95%). This means that the interaction between different doses of fertilizer and pruning will give different effects to the degree of polymerization. In single, the treatment of different fertilizer dose has a value of P = 0.0005, which means that the dose of different fertilizers give different influence to the degree of polymerization of yam bean tuber. The pruning treatment which has a value of P = 0.1266 means different pruning treatments do not give a different effect to the degree of polymerization of yam bean tuber.

The interaction of fertilizer dose and pruning, obtained yam bean tuber has a degree of polymerization ranged 8.50-28.75. Based on the

opinion of Roberfroid (1999) [2] which says that the degree of polymerization of inulin molecules is 2-60 +. It means fertilization treatment and pruning affects the degree of polymerisation of yam bean tuber. Effect of interaction of fertilizer dose and optimum pruning to increase the degree of polymerization of yam bean tuber is a combination of fertilizer doses of 125 kg ha^{-1} and without pruning. The optimum fertilizer dose on the treatment without pruning is 175 kg ha^{-1}, in the treatment of tip pruning, flower pruning as well as the pruning of tips and flowers is 125 kg ha^{-1}.

Table 3 Effect of NPK fertilizer dose and pruning on the degree of polymerization of Yam bean tuber.

	Pruning									
Fertilizer dose (kg/ha)	TP		PP		PB		PPPB		Average	
100	19,750	bcd	16,250	cdefg	16,250	cdefg	19,000	bcde	16,328	B
125	13,000	fghi	10,500	hi	28,750	a	22,000	b	18,973	A
150	14,750	defgh	12,750	fghi	12,750	fghi	13,500	efghi	14,821	B
175	20,750	bc	8,500	i	8,500	i	13,000	fghi	11,277	C
Average	17,063	A	16,563	AB	16,563	AB	16,875	B		

The value of P fertilizer dose = 0.0005; Pruning = 0.1266; Fertilizer * Pruning = 0.0000

Description: The numbers in the columns and lines followed by the same lower case indicate the effect of interactions with the dose of fertilizer and pruning which do not differ in the LSD test with a 95% confidence interval. The numbers in the column/row followed by the same capitalization indicate the single influence of the dose of fertilizer or pruning which do not differ in the LSD test with a 95% confidence interval. TP = no pruning, PP = tip pruning, PB = Flower pruning, PPPB = tip and flower pruning, P = significance value, * = interaction

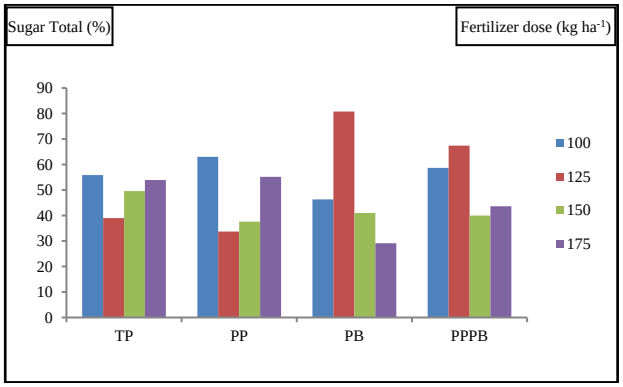

Fig. 3 Graph of fertilization influence and pruning on Total percentage of sugar yam bean tuber.

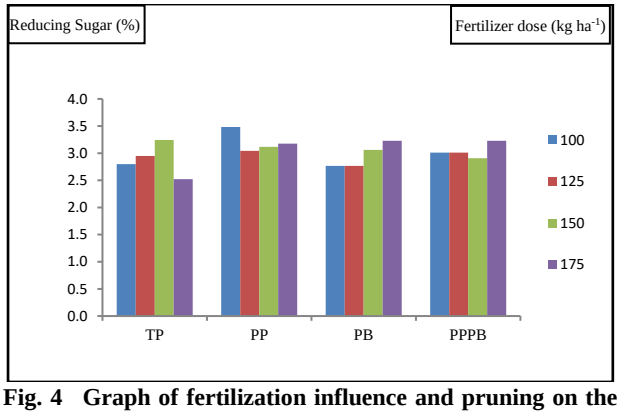

Fig. 4 Graph of fertilization influence and pruning on the percentage of reducing sugar yam bean tuber.

The optimum NPK fertilizer Dose (15:15:15) generally available to increase the degree of polymerization is 125 kg ha^{-1}. While the optimal pruning treatment is generally common is the treatment without pruning.

4. Conclusion

The experiments and analyses that have been conducted can be concluded as follows:

1) The interaction of fertilization and pruning does not affect the fresh weight of yam bean. The best NPK (15:15:15) fertilizer dose to increase wet tuber weight is 175 kg ha-1 combined with tips pruning and flowers.
2) The percentage of inulin levels obtained because of the treatment of fertilization dose and different pruning is 9.36-24.39%. Highest Inulin rate obtained from the treatment NPK fertilizer dose 125 kg ha^{-1} combined with thepruning of tips.
3) The treatment fertilization dose and different prunning produces tuber inulin with a

polymerisation degree of 8.50-28.75. The highest degree of polymerisation is obtained by combining fertilizing treatment 125 kg ha^{-1} with the pruning of tips.

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Great Guardians the Sustainable Success of the Community That Exercises Environmental Justice to Conserve the Ecosystems and Their Natural Resources of Quintana Roo, Mexico

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Office of the Environmental Protection of State of Quintana Roo, Mexico

Abstract: "Citizens Trained in the Protection of the Environment of the State of Quintana Roo, México, to care for the natural resources of the state and the planet", through the development of new concepts and legal instruments, under that society can use environmental legislation for conservation and sustainable development. Building good governance involves. To complex network of relationships that includes decision-makers and the whole society, through mechanisms that guarantee citizens full accessibility to the exercise of public function. It also provides co-responsibility for solving problems. Environmental justice within the law Plough already priority public policies of urgent attention with linkage, involvement and citizen co-responsibility with all levels of government.

Key words: justice, environmental, right, environmental

1. Introduction

The first demonstration of life of the human being when being born, is to the moment to have contact with the molecule of the Oxygen, a product that offer us the ecosystems of the planet, involved in all human activity and that does not have economic value in the finances publish or deprived of all the planet.

Therefore, protect, restore, conserve and take advantage of way sustainable the natural resources has gone back a subject of environmental justice, since the oxygen has to be considered like a popular collective property in the society boosting habits of participation and of commitment to be able to resolve the grave problems that the Climatic Change is presenting inside our time of visit like individuals in the planet. We live in already a subject world to environmental and economic effects that they transcend the national borders.

The increasing globalization has given place to a main recognition of the need to tackle of immediate way these questions.

In these moments, all the countries of the world find working with direct actions in mitigating the gases of effect greenhouse with international measures, national or domestic, so that the climatic change do not affect to future the world-wide economy and the development, the alimentary security and the ecosystems. The final aim this in that the worldwide temperature will not have to exceed the two degrees Celsius.

Quintana Roo, Mexico, is part of this process, especially by his predominance and identity in the conservation of the environmental services of his ecosystems, treating no only to fulfill, but contribute with multiple actions to increase these already known

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values, by what the Environmental Justice establishes it in his territory like a fundamental statement that pursues to endow of knowledge to all his citizens like tool to consolidate this put biotic. Model designated "Community Guardian".

This model to that does reference was presenting to debate in front of the World-wide Commission of Environmental Right (WCEL), those who like coordinators of the Conference of Judges and Fiscal on Justice specialized in environment, they extern a series of actions in the process politician realized in the 8th World-wide Forum of the Water celebrated of the day 18 to 23 March 2018, in Brasilia (Brazil). Important is the quotation that for the first time has gathered to the procurators, public ministries, judges and fiscal, in a forum where argue the environmental subjects by the skilled collectivity of the planet, and in union with: the World-wide Council of the Water, the one of Environment of the United Nations, the one of the Organization of American States and the World-wide Judicial Institute on the Environment, concluded in his group, that owe to improve practices to enforce the laws, norms and regulations that apply to the environmental subjects and guarantee the effective access to the justice of the water (Letter Brasilia).

Likewise, the World-wide Commission of the Environmental Right, pertaining to the World Commission on Environmental Law (IUCN), decide to create and found, by unanimity, the "Global Institute of the Public Ministry for the Environment".

They know innumerable discussions in multitudinous forums and that have manifested on the relation that exists between the environment, his deterioration and the links that saves with the social and economic development waking up until the academic interest by part of researchers of diverse educational institutions, those who question the conception of progress and the ecological disequilibrium like a conflictive relation. (Informative agency CONACYT, 2018, celebrated forum in the Meritorious Autonomous University of Populate).

By the previously described and can realize the actions that show that they can carry harmonious relations balanced between the human needs regarding the natural resources, his conservation and sustainable development and in what it corresponds to the sustainability in the state of Quintana Roo, Mexico, has proposed the implementation of the environmental justice del model designated community guardians, with the following:

2. Aims

2.1 Guardians Comunitarios

Citizens trained in the Protection to the Environment of the state of Quintana Roo, to take care the natural resources of the state and the planet", by means of the development of new concepts and legal instruments, of such way that the society can employ the environmental legislation for the conservation and the sustainable development.

Build a good government by means of the opening of his performance to the public scrutiny through mechanisms that guarantee to the citizen total accessibility to the exercise of the public function.

Likewise, endow of co-responsibility to the citizen to solve the environmental problems of his location.

Endow of information to each person in his everydayness so that it purchase consciousness and answer of suitable way to solve the problems of ecological type-environmental or of another dimension that arise.

3. Methodology

The International Union for the Conservation of the Nature (UICN) proposed, in 1970, the definition of Environmental Education: "Process to recognize values and clear concepts to create skills and necessary attitudes, tending to comprise and appreciate the mutual relation between the man, his culture and the half biophysical surrounding. The environmental education (EA) also includes the practice to take decisions and formulate a code of behavior with regard

to questions that concern to the environmental quality. Therefore, the environmental education is a continuous process in which the individuals and the collectivity take consciousness of his half and purchase the values, the competitions and the will to do them able to act in the resolution of the current problems and futures of the environment.

The environmental education (EA) purchases his international patent in the year of 1972 with the "Statement of Stockholm and Latin America", and begins to practice a decade later in the continent (González, 2000).

In Mexico, of governmental way begins with the EA by means of the creation of the CECADESU (Centre of Qualification for the Development Sustainable), in the year of 1994 like part of the SEMARNAP (Office of Environment, Natural Resources and Fishing). And in the formal education, the universities that collaborate directly with this thematic have been: the Universidad Iberoamericana, the ITESM (Instituto Tecnológico y de Estudios Superiores de Monterrey), the ITAM (Instituto Tecnológico Autónomo de México with specific programs in environmental education. Also the PNUMA (Program of the United Nations for the environment), has developed important programs with the aim to include to the civil society and create an environmental consciousness. (Universidad Tecnológica de México, 2006).

In the year of 2016, the Procuraduría de Protección al Ambiente del estado de Quintana Roo, México (PPA), adopts the methodological approach of the UICN for the investigation designated like participatory action, to end of;

- Gather information on the problematic environmental in the state.
- Analysis and identification of contents of the plan and program community guardians.
- Implementations of actions specify: Announcement, forming and formalization of constitutive record of the organization community guardians by community in links with the PPA.
- Provide of teams and tools adapted for the realization of the work in each community.

The development of analysis, is by:

- Workshop diagnostic.
- Workshops of planning.
- Environmental technical workshops.
- Workshop of evaluation and follow-up.

By means of the application of questionnaires, adapted of the Methodological Guide for the Formulation and Evaluation of Projects of environmental Education under a Participatory Approach (Ramírez, 2004) and Chamorro (2006), environmental Education in the public administration.

The EA, by means of workshops of following qualification:

- Workshop 01: How exert your rights in the defense of the environment?
- Workshop 02: "The management of the environment and the administrative competitions".
- Workshop 03: "General Diagram of Federal Competitions, State and Municipal".
- Workshop 04: "The Right of Access to the Environmental Information".
- Workshop 05: How Take part in the Legal Procedures?
- Workshop 06: What do when it breaks the law?
- Workshop 07: have Technicians of Restoration of Ecosystems and interpretation of the Program of Ecological Legislation Venue.

4. Results and Discussion

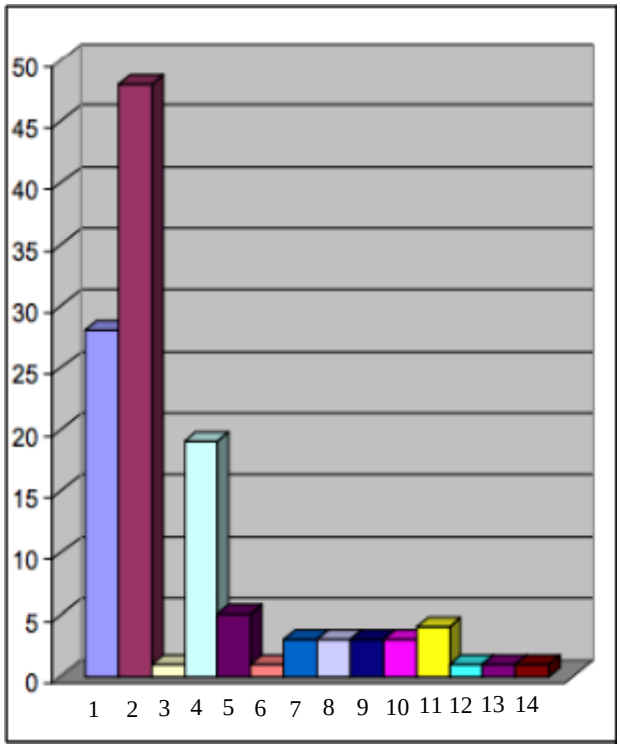
Table 1 Group put community guardians.

Name	Location	Trainers	Lawyers
La Savannah	Chetumal	12	10
El Manatí	Calderitas	6	10
La Laguna	Bacalar	10	10

*Locations selected in the investigation.

Table 2 Diagnose: Realized by conservatoires with the communities selected for the investigation.

Location	People gathered by the announcement	Identification of environmental problems to resolve
Chetumal	183	14
Calderitas	87	9
Bacalar	91	11



1. Rubbish 2. Water 3. Soil pollution 4. Deforestation
5. Predation and hunting 6. Children not neat 7. Air pollution
8. Without citizen interest to the Environment 9. Erosion
10. Dirty streets 11. Rats and cockroaches 12. Waste
13. There is no data 14. Pollution

Fig. 1 Problems Identified in communities object of the investigation.

Table 3 Workshops of qualification.

No. Trainers	Training workshops	Location
8	01.02.03.04.05.06.07.	Chetumal
5	01.02.03.04.05	Calderitas
6	01.02.03.04.05.06	Bacalar

Project Pilot "La Sabana", Chetumal, Quintana Roo, Mexico, of involvement of all the organs of government and society, for the restitution of the environmental services, has application of the committee of Community Guardians, results:

Location	Chetumal
Ecosystem disturbed	Body of water, La Sabana
Actions promoted for his recovery	18
Organisms Involvement of the three organs of government	11
Social organizations	3
Citizens	63
Results obtained	Project of restoration of body of water, with the Involvement voluntary of all the organs of government and the orderly acceptance and recognized by the society in his whole
Evaluation and Follow-up	The sanitation has measured by means of factors of risks on health, conditioned by attitudes and unsuitable practices to familiar level, community like a function of the Public Health with the purpose to control, diminish or delete risks derived of the present conditions in the physical and social environment of the body of water. Reporting The Office of Health of the Government of the state like stable without affectations to the health and the body of water endows of comfort to the individual or to the community.

Links with the three levels of government in Mexico coordinated by the Procuraduría de Protección al Ambiente del estado de Quintana Roo, México, Involvement the Office of Marina, CONAGUA, SESA, ECOSUR, PROFEPA, SEMA, PPA, Municipio de Othón P. Blanco, state and municipal Civil defence, Office of Public Security, Police, Union of Stone freight trucks and Citizenship conformed by the settlers of the neighbors to the body of water coordinated by the committee of Community Guardians where belong the native groups Mayas of the region.

The application of the technicians of analysis, planning, and realization of technical workshops, gives like result, the need of forming of ten committees of Community Guardians for all the state, and that to his time integrate it ten people selected to collaborate of

firm way and decided in the actions of surveillance for the protection and conservation of the natural resources in the different pertaining ecosystems in territory to Quintana Roo, Mexico, and that of individual or collective form summoning to the private sectors and social of each community, of equal voluntary and conscious way, with the firm commitment to respect the normativity, regulation and environmental legislation in force that applies in the so much federal states, state and municipal, under the principle to guarantee the exploitation and use sustainable of the natural resources and in contrary case report the illicit and/or environmental crimes in front of the PPA. Likewise, promote and guarantee the participation of the society of compliance with the had in the article 10 of the Law of Ecological Balance and the Protection to the state Environment, that has the promotion of the participation of the society in environmental matter, as well as the formulation and driving in matter of preservation and restoration of the ecological balance and protection to the environment. The authorities and the individuals have to assume the responsibility of the protection of the balance, as self-evident in the Law of Wild Life of the State of Quintana Roo, in his article fourth where signals that the aim of the state politics in matter of wild life and of his habitat is his conservation, by means of the protection and the requirement of optimum levels of sustainable use, so that simultaneously it attain keep and promote the restoration of his diversity and integrity, as well as increase the welfare of the inhabitants of the State; and in his fraction VIII where does reference to the participation of the owners and legitimate possessors of the properties in where it distribute the wild life, as well as of the people that share his habitat, in the conservation, the restoration and the derivative profits of the sustainable use.

To attain the participation decided, informed and responsible of the citizenship spreads by half workshops, that with foundation in him article 1º of the General Law of the Ecological Balance and the Protection to the Environment (LGEEPA), where signals that for propitiate the development sustainable and establish, between others, the bases to guarantee the responsible participation of the in shape individual people or collective, attain the preservation and the restoration of the ecological balance, as well as, to realize his functions, the citizen or Community Guardians bases his act in the Chapter IX of the Law of the Ecological Balance and the Protection to the Environment of the State of Quintana Roo (LEEPA), in where it establishes the mechanism of "Complaint In Environmental Matter", where will be able to report in front of the procuracy all fact, act or omission that produce or can produce ecological disequilibrium or damages to the environment or to the natural resources.

Procuraduría de Protección al Ambiente del estado de Quintana Roo, guarantees his act for being an Organ deconcentrated, endowed of technical and functional autonomy for the exercise of his attributions. The juridical disposals award to the procuracy the power to realize the investigations on the complaints of facts, acts or omissions that cause damage to the environment or represent grave risks for the same, in addition to watching, inspect and sanction all those rapes to the LEEPA, to the Law for the Prevention and the Integral Management of Waste, to the Law of Protection and Animal Welfare, all of the State of Quintana Roo and the other disposals of environmental character of State competition.

All the Community Guardians, have engaged to the constitutional precept and right of Law, like common purpose, for protecting, conserve, preserve and take advantage of rationally the natural resources, that conform the ecosystems in the State of Quintana Roo. Of equal form, is of vital importance the adoption of the ethical and his values Involving to the people of the communities for the establishment of the Environmental Justice in all the territory, of firm way and decided translating in actions of surveillance of voluntary and conscious way, with the firm commitment to respect the life in his environmental

surroundings, under the principle to guarantee the Involving and sustainable use of the natural resources and in contrary case report the illicit and/or environmental crimes in front of the procuracy, his follow-up until the total restitution of the damage.

5. Conclusions

The mankind faces to two big problems, the big violence against of the nature and the violence against the same man. It has shelved that both parts are at present in tension and have not conceived like complementary. It exists a false conception of the development because always it has equated with a mere economic growth, procuring the consumption in a market totally globalized, where access to goods and increase wealth is many times the base of the immoderate exploitation of the natural goods.

What can know, what can expect, what have to do and what is the man. They are questions typical that the sciences have concerned more for saying us who are, but lacking ask what is the world for the man. And it is here where the social metabolism goes in in scene and brings us the challenge to discover the foundations of the human action with the nature, and the very understood with the suitable knowledge on our environment is that it allows to the man act in harmony, but especially fraternity with the nature

Citizens trained in the Protection to the Environment of the state of Quintana Roo, to take care the natural resources of the state and the planet", by means of this model of "community guardians", that includes new concepts and legal instruments, of such way that the society can employ the environmental legislation in the Environmental Justice for the conservation and the sustainable development. Build a good government involves the opening of his performance to the public scrutiny through mechanisms that guarantee to the citizen total accessibility to the exercise of the public function, by means of the Technicians for the Information and Communication. Likewise, it endows of co-responsibility to each community to solve his environmental problems.

Each one of these elements, endows of information that does that each person in his everydayness purchase consciousness and answer of suitable way to attend the environmental subjects or of another dimension that arise.

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Potentials and Perspectives of Off-Site Technologies for the Existing Building Heritage in Italy

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Abstract: New systems of industrial production with the innovative materials and technological evolved systems contribute to the increase of the construction quality of the finished product: from a single technical element to the whole building. The new perspectives of the industrialization process manufacturing, for the purpose of upgrading the energy efficiency, offer, in fact, a wide range of possibilities on the existing intervention with the purpose of the remedy for the low levels of performance and re-placing a product on the market which an increased value in the face of greater energy efficiency. The main factors that affect the feasibility and type of intervention are three: price, time of realization and payback times. In light of this, the building sector changes more and more quickly its nature: from on-site becomes off-site moving from the yard to the factory where, by binding to the manufacturing processes, implements the effectiveness of the construction industry and secures greater results in terms of energy retrofit. A change that affects industrial processes, products and construction sites increasingly oriented towards the aggregation of prefabricated or semi-prefabricated elements instead of on-field construction.

Key words: sustainability, energy retrofit, off-site construction, integrated solutions, redevelopment

1. Introduction

Most of the energy consumption in Italy is attributable to the civil use sector, having represented 39.3% of total consumption in 2015, exceeding the consumption deriving from the transport sector by 7.2% [1]; a significant figure accentuated by the remarkable consistency of the Italian housing stock: of over 12 million residential buildings [2], approximately 53.7% are over 40 years of age as they were built before 1970 and, therefore, before the issue of the energy efficiency standard and the anti-seismic standard [3]. There is also a further 31% to be considered built in the following twenty years (1971-1990) and 7.4% in the last decade of the 20th century so as to go to constitute a considerable stock of buildings that is more than 30 years old [4].

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The interventions on the real estate, in terms of energy requalification, represent a sector in strong growth, given the increasing availability of buildings, in which all the operators of the construction process pour. On the one hand, innovation and on the other, the context that becomes increasingly wider if we consider the continuous comparison with the main emergencies affecting the whole planet: the rise in temperatures, the maximum concentration of carbon dioxide in the atmosphere and, above all, the non-renewability of resources. The interventions aimed at greater energy efficiency of buildings represent one of the many tools available to overcome these challenges also by virtue of the objective, now expiring, for Europe, according to the requirements of the European Directive 2010/31/EU [5].

By the Emergency Efficiency Report, from the Energy & Strategy Group of the Politecnico di Milano [6], in 2017 the overall total of investments made in Italy was equal to approximately 6.7 billion euro

confirming the positive trend of the last 5 years which, by operators in the sector, seems to be confirmed also during the first half of 2018. The ranking of investments sees the Home & Building segment excel — with 65% of the total — affected by various solutions and technologies concerning the building: most of the investments are concentrated in heat pumps and cogeneration plants — 30% — but there is a good 16% growth as regards the interventions carried out on the envelope in terms of opaque and glass surfaces.

Considering new perspectives, surely, play a significant role the so-called Modern Methods of Construction, new building technologies, aimed especially at the upgrading of existing assets and to its transformation with renewed energy and environmental performance and sustainable cost time. A renewed range of products in which converge both materials and the shaped components for a better integration with the "built" technologies of existing buildings, controllable and manageable thanks also to the introduction of new methods of digital modelling as the BIM.

Innovation and sustainability, aimed at the redevelopment of the existing heritage, represent two key points on which to focus for an evolution of Architecture and its processes not only limited to the national but also European context: in fact the objectives defined by the EU 2020 ten-year strategy must continue to be a stimulus to research. The prevailing orientation is to develop ad hoc technical solutions that are increasingly customized in terms of product and standardized in terms of process: the goal is to have maximum yield with minimum waste.

2. Material and Methods

The construction technologies that use prefabricated components combine both the demands of the application and the performance requirements of the building itself. There are several experiences, both internationally and nationally, that have been able to combine performance efficiency — in terms of energy efficiency above all — with an economic sustainability of the intervention in relation to the reduction of on-site processing times. An example is the Dutch "Energiesprong" program, started in 2012, which provides for the redevelopment of over 100 thousand housing units to guarantee and take action to eliminate consumption over thirty years; thanks to the choices of the team commissioned by the Dutch Government, a large and diversified social housing stock was redeveloped with interventions on the envelope and on the systems in a very short time and with a significant reduction in consumption, reducing 40% of intervention costs in three years [7]. The same project was also presented in Italy in 2015, taking into consideration the possibility of intervening on the existing one through components made in the factory and "added" to the old structure [8].

There are many advantages of these technologies linked both to the installation in terms of times and operating phases and to the whole process that concerns them: design, production, construction site. The design phase, first of all, plays a fundamental role from the study of the raw material, with its parameterized physical and mechanical characteristics, to its digital model, allowing, from the beginning, to solve low-level construction nodes highly complex, reducing the risk of error during assembly time; the production phase, thanks to an evolution of industrial processes and the adoption of innovative instrumentation, allows, in a very short time, to have the finished product from the digital design; the construction phase represents the moment in which the components are assembled to support structure and between them, according to hierarchies, established during the design phase, which allow maximum performance in terms of geometry and mechanical characteristics and the collaboration between the elements [9]. Generally, metal and wooden components are used: while the first are already known in the building sector as support for internal partition elements as an internal addition to existing perimeter

walls to support coatings, the latter are spreading rapidly, especially in the international market, both for new constructions and above for the recovery of the existing.

The wooden components constitute light structures essentially attributable to two different construction systems for the geometry of the elements used but in any case, combinable with each other: frame structures - beams and columns - and load-bearing elements - panels. The use of innovative materials, such as engineered woods, contributes considerably to reinforcing this distinction: precisely for the production process that the material undergoes - wood - it is possible to obtain higher performance both in terms of mechanical strength and durability of the material. Among the different types of engineered woods, we focus on those that have achieved remarkable performance from a structural point of view: the LVL (Laminated Veneer Lumber) and the CLT (Cross Laminated Timber) [10]. The LVL is the basis for the construction of beams and columns, while the CLT is the basis for the realization of load-bearing panels, also known as X-lam or Cross-lam panels. The LVL elements are made up of several "sheets" of wood, generally very thin with thicknesses around 3 mm, obtained directly from the trunks of the trees, through mechanized procedures that prevent the use of instruments in sequence, and subsequently glued between them. This type of technology is particularly used for the construction of unidirectional elements such as beams and columns, allowing to reach even very large spans up to 24-25 m.

The construction system with load-bearing wooden panels based on CLT technology is a system based on solid wood panels with 90° crossed and glued "sheets" of wood (minimum 3 layers), with very variable thickness and dimensions. whose geometric characteristics depend on the necessary structural dimensioning, the technologies of the manufacturing companies and functional requirement [11]. They can be made with different essences: fir, pine and larch are the most common as they have better strength and durability characteristics for the construction. This system can be used to build both walls and floors of multi-storey buildings, generally on a foundation consisting of a reinforced concrete base. To understand how far these technologies can be pushed, the Mjøstårnet building — also known as the Mjøsa Tower — in Brumunddal, Norway is below mentioning (Fig. 1). Finished to build in March 2019 has been defined, during the same year, as the wooden building highest in the world with its 84.5 m, a record made official by the Council on Tall Buildings and Urban Habitat [12]. Mjøstårnet has a combined area of approximately 11,300 square meters. The building has 18 floors comprising apartments, a hotel, offices, a restaurant, a panoramic terrace and common areas. The CLT was used to make the partitions of the lift and stairs, while beams and columns were made of LVL through connections with steel plates and bolts. Although the choice to build the stair-lift block with wooden load-bearing elements can be considered innovative, there was the compromise of use of reinforced concrete for the flat deck of the last seven floors to increase the mass of the building to reduce the swing due to the wind [13].

The use of wood, in all its evolutions, can be considered a sustainable choice in terms of speed of execution and in terms of energy retrofit [14], but precisely for its very qualities, it can be considered a valid ally for interventions on the existing, in recent years, also in Italy.

The use of wood for the structural and energy requalification of existing buildings offers several advantages: lightness, versatility, resistance, good performance during earthquake and from an energy point of view. Furthermore, to have access to tax incentives, it makes it that constructive wood solutions are also choices to make elevations or extensions building in very fast time.

The most widespread technology used is based on X-lam panels, the choice of which is dictated by the

lightness of the material, which weighs to a lesser extent on the pre-existing structures, and by the speed of construction which allows to reduce the phases of building site. Another advantage is linked to the reduction of the impact on the environment: careful and scrupulous design minimizes the use of materials on site, transport and the production of waste. Residential and public-receptive buildings are increasingly seeing the use of these technologies: the need often derives from the possibilities that may exist on the increase in surface area or cubic capacity allowed by regional laws and, before these, by national laws. These are interventions that, although of limited size, weigh on existing structures - often in reinforced concrete that can be 60 years old and beyond — for which optimal performances are foreseen in terms of integration with existing technologies and energy improvement. As an example, we can consider the intervention carried out in Carole, in the province of Venice, at the "Hemingway Village" (Fig. 2): an expansion of three floors above the two existing buildings already characterized by three floors above ground. The tourist buildings have exploited the residual building capacity of the area and the bonuses of the Municipal House Plan which have allowed to increase the 30% of the existing useful surface and also to access important tax breaks. The technology used, X-lam panels, has been used to avoid overloading the existing structure too much and has had the additional effect of making an improvement in terms of energy retrofit and living comfort for the entire building. The duration of the construction site, of only 6 months, was less than the established time scheduled with the additional advantage for the activity to reopen to the public immediately after closing for the winter season. The up-extension work began in November 2010 with the removal of the existing roof and the preparation of the reinforced concrete curbs for the laying of the bearing structures in X-Lam panels.

Fig. 1 Mjøstårnet, Burmunddal, Norway, 2019 (from: http://buildingcue.it).

Fig. 2 Hemingway Village, Carole (VE), Italy. From: http://grandellihouse.it.

The wooden structures, inclusive of slabs walls and roof, were completed in January 2011. The realization of the interior with plants, false walls, doors, floors and finishes is in contemporary external casing was performed to coat with closure of the yard and inauguration May 2011. The existing apartments on the 3rd floor have been transformed and raised into duplex apartments, taking advantage of the entire 4th floor, in order to optimize the heights and create a clear division between the living area, on the lower level, and the sleeping area , on the upper level. The 5th and 6th floors, on the other hand, are characterized by one-room, two-room and three-room apartments in order to offer a different range of housing types. The internal distribution has also been revised according to the accessibility of the new floors, made by extending the current stairwell made of reinforced concrete. It should be emphasized how the use of X-lam technology has allowed the use of other construction technologies to support the improvement of energy performance such as external insulation with finish with heat-insulating varnishes, to increase yields energy of the building, and the installation of wooden windows and finally it allowed to maintain the external image of the building without altering the original typological characteristics [15]. The use of wood in general, and X-lam panels in particular, is becoming a custom especially for interventions, which are limited in invasive nature, to be carried out quickly; the technical process begins with a correct design of the elements to be used as well as the connections between them and the existing structure — the critical points — continues with the realization of the elements in the factory and continues on the construction site with a double action: the preparation of the support, freed and cleaned of all that does not belong to the system of structural elements and the “assembly” of the elements in X-lam, with the appropriate connection systems. The procedure, thus standardized, could also be extended to larger buildings of the single-family house, as shown by the project of the accommodation facility in Venice, but could even go beyond the addition to the existing intervention to take the form of integration with the existing. Let’s think, for example, of the possibilities that could exist if, by redeveloping an entire building from the 70s-80s, the most common in Italy, all external infill elements could be replaced with X-lam panels: the intervention would certainly reduce construction time, with substantial savings on all the costs deriving from it, and it would certainly increase the energy performance of the building. Just a consideration: an average transmittance value obtainable by external insulation with rock wool panels on the perimeter brick wall is around 0.30 W/m^2K, while, using the same type of insulation — wool panels of rock — but on an X-lam support, a transmittance value of around 0.18 W/m^2K could be obtained; a considerable reduction, normally obtainable only with

a high thickness of insulating materials and all the disadvantages that this entails.

3. Results and Discussion

The use of wood in general, and X-lam panels in particular, is becoming a custom especially for interventions, which are limited in invasive nature, to be carried out quickly; the technical process begins with a correct design of the elements to be used as well as the connections between them and the existing structure — the critical points — continues with the realization of the elements in the factory and continues on the construction site with a double action: the preparation of the support, freed and cleaned of all that does not belong to the system of structural elements and the "assembly" of the elements in X-lam, with the appropriate connection systems. The procedure, thus standardized, could also be extended to larger buildings of the single-family house, as shown by the project of the accommodation facility in Venice, but could even go beyond the addition to the existing intervention to take the form of integration with the existing. Let's think, for example, of the possibilities that could exist if, by redeveloping an entire building from the 70s-80s, the most common in Italy, all external infill elements could be replaced with X-lam panels: the intervention would certainly reduce construction time, with substantial savings on all the costs deriving from it, and it would certainly increase the energy performance of the building. Just a consideration: an average transmittance value obtainable by external insulation with rock wool panels on the perimeter brick wall is around 0.30 W/m^2K, while, using the same type of insulation — wool panels of rock — but on an X-lam support, a transmittance value of around 0.18 W/m^2 could be obtained; a considerable reduction, normally obtainable only with a high thickness of insulating materials and all the disadvantages that this entails. The complexity of the theme of technical and management thermal requalification is well known, but the contents of these interventions are still rather cumbersome and uncertain thanks to a wide range of solutions accompanied by a lack of awareness of their potential due to the absence of a systematization of existing technologies. The variability of the raw material on which to intervene — the existing heritage — assumes a fundamental role in the evaluation of the type of intervention and this is often made conditional to a slowdown in the initiation of the interventions themselves. It is essential for the entire sector and for all operators entire the sector to acquire greater confidence in new construction technologies that can be acquired through greater knowledge and awareness in order to operate with renewed technical efficiency. Producing more efficiently, reducing time and development costs: these objectives do not should only be signs without foundation, but all the buildings sector with its operators should focus on the emerging technologies of manufacture directed from digital infrastructure to combine production series and variety of goods produced. New parameters for assessing the feasibility of the interventions therefore come into play: the reliability of the assets, the traceability of the components, the programmable maintenance, as well as the containment of energy costs with a view to retrofitting the existing one. The off-site construction is not a specific technology, but rather a set of experiments which covers all the technologies available in all operational areas of construction and above can converge in reuse and in the existing retraining. The innovation lies in using knowledge already developed in some industrial sectors to turn it to more precise and targeted purposes to give a concrete answer to a question that is continuously updated and compared with environmental sustainability targets to be achieved. From the status of art, business networks and production chains, specialized in research and application of technologies for sustainable construction aimed at and interventions on the existing could be enhanced for their intelligent management; it really could lead to integration with advanced technological systems such as smart living

technologies: a concrete support to architectural practice which is able to offer solutions that will answer to the needs of the client, responding, at the same time, in an exhaustive way to the challenges of the green economy.

4. Conclusions

The negative decline of the last ten years in Italy, mainly due to the drop in new buildings, has led to the reformulation of the list of priorities in the construction sector: in particular the reuse of public and private assets, housing and infrastructure has become central, while, more and more, the realization of new interventions has assumed a marginal role. If the strategies and the way forward for a recovery of the sector, for the near future, appear to be substantially shared, the path leading to a lasting development of the sector is less outlined. It could be possible to identify interventions applicable to the building heritage in a transversal direction to increase well-being and comfort but at the same time reduce costs and times of the intervention: interventions that cannot be scheduled by the intended use of the buildings and building typology but for integration with existing construction technologies by evaluating their implementation with HI-dom support systems. The real innovation lies both in the introduction of new materials with variable performance, selectable and controllable thanks to physical-chemical alterations and, above all, in the use of new laying and assembly techniques while resorting to traditional materials exploiting their physical characteristics, as we have seen in the case of wood, in relation to the renewable nature of the raw material and the sustainability of the production processes. Within the same matter the answers can be found for a new economy based on the awareness that the technologies and knowledge available are no longer enough to solve the current needs of sustainability [16]. Innovation, competitiveness and sustainability, aimed at redeveloping the existing heritage, represent three key points on which to continue to focus in order to definitively overcome the persistent gaps in the existing heritage.

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Optimization of the Geopolymer Obtaining Process to Immobilize Mercury and Its Mechanical Evaluation

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Abstract: The objective of this work was to form a geopolymer based on pumice stone and kaolin treated thermally, basic activating solution with sodium silicate solution ($Na_2SiO_3.nH_2O$) in order to immobilize solid mining waste (SMW). The influence of various physical factors during its elaboration and the response of the formed Geopolymer with the SMW previously stabilized were determined. The predominant physical factor evaluated was the resistance to compression, according to ASTM C-1157 method, which is a determining factor in the durability of the formed geopolymers. The results show a maximum of 34.70 MPa in a randomized treatment with levels (1:1, 8 and 60) of the studied factors and a minimum of 12.49 MPa with the factors (3:1, 4 and 20). The percentage ratio of the optimal geopolymerizing material formed to immobilize mercury present in the residue was 55% pumice stone, 45% metakaolin with a liquid/solid ratio of 0.4 and 10 Molar concentration of basic solution. This aluminosilicate synthetic material could well replace other materials. A complete factorial design with three central tests was used, applying the Statigraphics Centurion XVI software.

Key words: geopolymer, mercury, pumice stone, mining waste, compressive strength

1. Introduction

The southern middle region of Perú that comprises regions of Ica and Arequipa have polymetallic mining wealth exploited on a large, medium and small scale, being the small gold and artisanal mining, which predominates in the coastal area of this part of the country dedicated to the exploitation of gold. The technology used is the amalgamation process with mercury and in others through cyanidation [1] which when used and handled improperly; generate solid mining waste (SMW) with a high content of mercury and other toxic metals, causing serious damage to health and the environment irreversibly [2, 3].

Mercury is currently considered one of the global pollutants, a very dangerous toxic element that has no borders because it is transported by the wind hundreds of kilometers from the point of release due to its very peculiar physical and chemical properties compared to other dangerous and radioactive toxic elements [4]. Geopolymers are called green cement [5, 6] for their properties (high mechanical strength, fire resistance, acid resistance, low thermal conductivity and fast setting times [7] and low environmental impact by using raw materials such as industrial by-products, thermally treated natural clays, volcanic rocks [8, 9] and other materials that are available on a large scale and with CO_2 gas emissions close to 0.184 tons, which is the sixth part of what emit other industries such as cement plants [10]. Geopolymers act similarly to cement binder in terms of encapsulation; however, the physical and chemical properties of the product may be

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much higher and better than those treated with traditional cementitious materials [11] because properties of geopolymer have high resistance to mechanical compression, resistance to acid attack (high solubility of heavy metals at low pH), low permeability and high durability [12]. The objective of the present study was to evaluate the performance in terms of compressive strength of the geopolymeric material formed from pumice stone and metakaolin in the encapsulation [13] of the previously characterized [14] and stabilized Solid Mineral Residues (SMW).

2. Experimental Work

2.1 Method

The present study had two phases; the first was to find the optimal formulation of the geopolymer by varying two parameters: the percentage ratio of metakaolin (MK) with respect to pumice stone (PS) as raw materials and the concentration of basic solution.

We used as a base material of the geopolymer: PS whose chemical composition was determined by the test method 592 for alkaline fusion rocks, MK was achieved after subjecting a thermic treatment the kaolin for four hours, with a specific chemical composition by X-ray Fluorescence (ARL-dry base), (Table 1). For the activating solution, a basic solution of 98.3% purity, commercial sodium silicate solution and 55% H_2O was used with a volume ratio of sodium silicate/basic solution equal to 1. Then four formulations of raw material were prepared with different percentage compositions of PS and MK (45/55, 55/45, 65/35, 75/25) using basic solutions at different concentrations: 1 M, 3 M, 5 M, 7 M and 10 M to determine the optimal formulation for the procedure of the synthesis of the geopolymer. The mixing time was 10 minutes, stirring speed from 1500 to 2000 rpm, curing time for 28 days under ambient temperature conditions (23 ± 2°C) and relative humidity of 60%.

In the second phase after determining the optimal formulation of the geopolymer, the previously stabilized solid mining waste (SMW-S) was incorporated according to a factorial experimental design with three central points to achieve the immobilization of the mercury present in the residue.

The characteristic toxicity leaching procedure (TCLP, EPA, 1311) is a method of extracting soil samples and also applicable to solid waste for chemical analysis used as an analytical method to simulate leaching. TCLP toxicological tests of both the mining waste and the product obtained were performed to see if the degree of toxicity decreases after the treatments.

The evaluation test on resistance to mechanical compression was evaluated at 28 days of age (ASTM C-1157), with a constant load of 0.024 in/min using the NTP 334.051: 2013 test method and as reference the standard ASTM C-109. For the data analysis the Statigraphics Centurion XVI software was used.

3. Results and Discussion

3.1 Chemical characterization of Pumice Stone and Metakaolin

The results that show the previous Table 1 of the chemical analysis to the pumice stone and the metakaolin demonstrate that they are suitable materials to form geopolymers, considering that the percentage of alumina and silica add up to more than 70% of the total.

3.2 Geopolymer Training and Optimization

In the geopolymer formation process, tests were

Table 1 Chemical composition (% by weight) of the base materials for the formation of the Geopolymerv.

Chemical compound	Molecular formular	Meta kaolin	Pumice Stone
Silicon oxide	SiO_2	76.92	63.58
Aluminum oxide	Al_2O_3	21.82	10.50
Iron Oxide	Fe_2O_3	0.31	2.66
Calcium oxide	CaO	0.01	1.72
Magnesium oxide	MgO	0.02	0.69
Manganese oxide	Mn_2O_3	0.18	0.26
Sodium Oxide	Na_2O	0.09	9.43
Potassium Oxide	K_2O	0.24	2.92
LOI	LOI	0.17	4.70

previously carried out to obtain the optimal parameters and their performance was evaluated by means of compression resistance (RC) measurements. Table 2 shows the results of the RC varying the percentage composition of pumice stone with respect to metakaolin ranging from 45 to 75% for the first and 55% to 25% for the second, in order to achieve a formulation with one more RC high, for this, the concentration of basic solution was equal to 10 M for all treatments is taken as a reference, value referenced and recommended by Barbosa [15] as well as Hardjito [16] who obtained high values of resistance to compression of geopolymers in a range of 8 to 20 M basic solution. The molar ratios of the main oxides varied as shown in Table 2 due to the variation of the composition, while the liquid/solid ratio (L/S) remains constant at 0.374. As a result, the highest compression resistance value of 41.67 MPa was obtained in the 2B treatment with a formulation of the Na2O/SiO2, SiO2/Al2O3 and H_2O/Na_2O molar ratios at (0.24, 5.82 and 8.78) respectively and that it corresponds to a percentage composition of 55% pumice stone and 45% metakaolin, while the other treatments were not very encouraging. Once the optimum composition of the base raw material is achieved, it is necessary to confirm that the concentration of basic solution is as indicated so we did.

Table 2 Compressive strength of geopolymer formed with different percentages of pumice stone and metakaolin, with basic solution 10M.

Treatment	%(PP +MK)	Ratio Molar			Compression Resistance (MPa)
		$Na_2O/Si0_2$	SiO_2/Al_2O_3	H_2O/Na_2O	
1B	45+55	0.17	7.00	9.25	24.71
2B	55+45	0.24	5.82	8.78	41.67
3B	65+35	0.25	6.64	8.34	19.61
4B	75+25	0.26	7.69	7.95	5.3

Table 3 presents the compressive strengths for the five treatments, keeping the SiO_2/Al_2O_3 molar ratio constant at 5.83 and the sodium silicate content with a volume ratio of 1: 1; the Liquid/Solid (L/S) ratio at 0.374 and the other molar ratios of Na_2O/SiO_2 and H_2O/Na_2O vary in treatments depending on the concentration of the basic solution directly for Na_2O/SiO_2 and inversely for H_2O/Na_2O treatment five (T5), achieved the best compressive strength of 23.2 MPa corresponding to the 10 M concentration with molar ratios of Na_2O/SiO_2 equal to 0.25 and H_2O/Na_2O equal to 8.78, a result that is a function of the composition optimum of the geopolymer made as shown in Table 2 corresponding to treatment 2B, where a high value of mechanical compression was also obtained.

With these five treatments it is shown that the initially tested base concentration of 10M achieves the best response to mechanical compression, as mentioned by different authors [15, 17, 18].

Table 3 Compressive strength of geopolymer* by varying the concentrations of the basic solution and keeping the SiO2/Al2O3 molar concentration constant at 5.83.

Treatment	Base (M)	Ratio Molar		(CR) (MPa)
		Na_2O/SiO_2	**H2O/Na2O**	
T1	1M	0.15	14.83	0.3
T2	3M	0.17	13.01	1.3
T3	5M	0.19	11.58	3.9
T4	7M	0.22	10.35	10.0
T5	10M	0.25	8.78	23.2

*55% PP y 45 % MK

3.3 Immobilization of Mercury in Stabilized Mining Residue Sample with Geopolymer Formed

Once the formulation of the raw material (55% of PP and 45% of MK) was optimized, concentration of the activating solution (10 M), sodium silicate and L/S

ratio of 0.374 for the formation of the geopolymer was carried out immobilization of RSM-E, 2C following the same methodology of the geopolymer formation process according to the mix design and established process conditions, as shown in Table 4 for the 11 treatments. The last three are central treatments according to factorial design.

After obtaining the Geopolymer containing SMW-S for the eleven treatments, treatment seven was selected because it had a higher mechanical compression response compared to the other treatments. The toxicity was evaluated after 28 days of curing by means of the TCLP test method (EPA-1311 method), resulting in a decrease of the content of the mercury metal in the mining residue from 90% to 95%, as can be observe in Table 5. The result obtained compared to the National and International regulations, in the process of immobilization of the mine waste with the geopolymer formed, indicates that the mercury contaminant is immobilized.

Table 4 Mix design and process conditions of the Geopolymer formation with RSM-E and basic solution in 40.0 y 60.0 g.

Treatment	SMW-S (g) 2C*	Pumice stone (g)	Metakaolin (g)	Sodium silicate (g)
1	256	35.2	28.8	58.52
2	256	35.2	28.8	60.80
3	256	35.2	28.8	63.08
4	256	35.2	28.8	64.60
5	128	105.6	86.4	95.00
6	128	105.6	86.4	87.40
7	128	105.6	86.4	79.80
8	128	105.6	86.4	76.00
1-C	192	70.40	57.60	68.40
2-C	192	70.40	57.60	68.40
3-C	192	70.40	57.60	68.40

Table 5 Comparison of the result of the concentration of Hg in leachate with the national and international regulations.

Elemento contaminante	Mercurio en Residuo 2C* (mg/Kg)	ECA Perú suelos según D.S. 002-2013-MINAM (zona industrial)	Normativa Internacional (USEPA, 2012b)				TCLP en geopolímero con RSM-E	Observación
			Solido general		Solido restringido			
			CCS (mg/Kg)	TCLP (mg/L)	CCS (mg/Kg)	TCLP (mg/L)		
Mercurio (Hg)	>225	24	50	0.2	200	0.8	< 0.001	Cumple normativa (N-I)**

*Sample of the area of Secocha- Camaná -Arequipa

** National and International Regulations

3.4 Mechanical Compression Resistance Analysis

The eleven values of Compressive Strength (MPa), shown in Table 6, obtained according to the mix design of Table 4, show three blocks of differentiated values that are somehow associated with the percentage ratio of geopolymeric material with respect to stabilized mining solid residue, SMW-S; treatments 1 to 4 with an average value of 13.63 MPa, the second block corresponding to treatments 5 to 8 with an average value of 31.37 MPa, value twice as high as the first block, result associated with the content of geopolymerizing material in the proportion of 60/40, where there is a greater amount of geopolymerizing material with respect to the SMW-S, the third block presents values of the central points with an average value of 27.37 MPa, it can be concluded that the best values are in the specimens with the highest content of geopolymerizing material, as seen in Fig. 1.

Fig. 2 shows the standardized Pareto chart to see which factor has the greatest impact, as the only factor that has an important impact is the variable C (ratio of geopolymerizing material (MG) and SMW-S) that has an effect of 17.45 MPa and that positively affects maximizing CR. This analysis is corroborated with the statistical analysis applied, as shown in Table 7 regarding the participation of the three factors studied that influence the performance of this property.

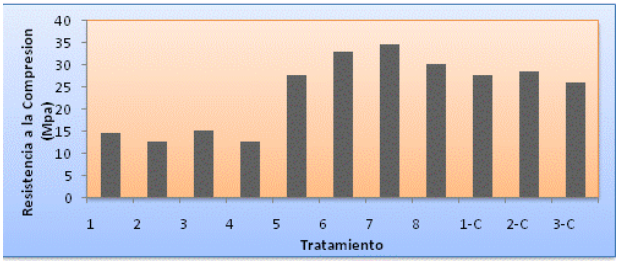

Fig. 1 Compressive strength (MPa) of monoliths.

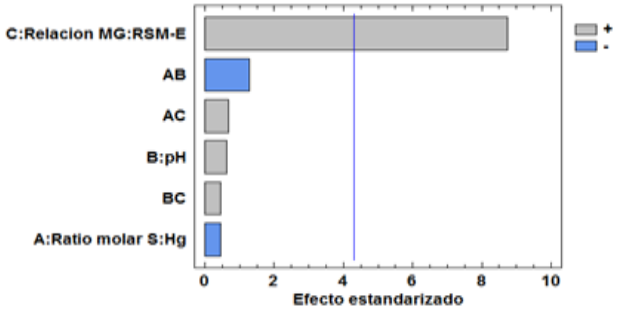

Fig. 2 Standardized pareto diagram for compression resistance.

Table 6 Factorial design matrix 23 with 3 central replicas and variable compression resistance response in (MPa).

N° Trat.	Factor real*			Factores de Diseño							Resistencia Compresión
	Z_1	Z_2	Z_3	A	B	C	AB	AC	BC	ABC	
1	1:1	4	20	-1	-1	-1	+1	+1	+1	+1	14.41
2	3:1	4	20	+1	-1	-1	-1	-1	+1	+1	12.49
3	1:1	8	20	-1	+1	-1	-1	+1	-1	+1	15.12
4	3:1	8	20	+1	+1	-1	+1	-1	-1	-1	12.49
5	1:1	4	60	-1	-1	+1	+1	-1	-1	+1	27.58
6	3:1	4	60	+1	-1	+1	-1	+1	-1	-1	32.92
7	1:1	8	60	-1	+1	+1	-1	-1	+1	-1	34.70
8	3:1	8	60	+1	+1	+1	+1	+1	+1	+1	30.29
1-C	2:1	6	40	0	0	0					27.65
2-C	2:1	6	40	0	0	0					28.48
3-C	2:1	6	40	0	0	0					25.98

Z1 (Ratio molar: stabilizing reagent: Hg en SMW), Z2 (pH) y Z3 (Dose in % weight geopolymerizer); A= Z1, B = Z2 y C = Z3

Table 7 Analysis of ANOVA variance of compressive strength in the process of immobilization of SMW containing mercury.

Source of variation	Sum of square	**GI**	Middle square	Reason-F	Value-P
A:Ratio molar S:Hg	1.63805	1	1.63805	0.2	0.6997
B:pH	3.38	1	3.38	0.41	0.588
C: relationship MG:RSM-E	629.77	1	629.77	76.19	0.0129
AB	13.6765	1	13.6765	1.65	0.3271
AC	3.7538	1	3.7538	0.45	0.5698
BC	1.78605	1	1.78605	0.22	0.6877
Lack of adjustment	26.4364	2	13.2182	1.6	0.3847
Pure error	16.5313	2	8.26563		
Total (corr.)	696.972	10			

The improved ANOVA variance analysis (ABC interaction is excluded) individually analyzes the Compression Resistance variability for each of the effects. The ANOVA tests the statistical significance of each effect by comparing its mean square against an estimate of the experimental error, the variable C has a P-value (0.0129) less than 0.05, with a confidence level of 95.0%, therefore it is concluded that factor C is statistically significant, while the other factors are not statistically significant.

This result confirms the preliminary analyzes performed, also in the same table it is noted that the

lack of adjustment has a value of 0.3847 above 0.05, being non-significant therefore does not present curvature and the model has a linear behavior.

3.5 Prediction

To predict the compressive strengths in the best treatment obtained (A ±, B + and C +) or in any other treatment that is to be checked, the regression model adjusted to the best ANOVA in table 7 is obtained and is given by Eq. (1):

$$\hat{Y} = 23.24 + 8.87\ C \quad (1)$$

The regression model associated with the analysis of improved variance interprets according to the coefficient of determination R2aj 84.58% of the variability in maximizing the compressive strength of the specimen formed, this quite optimal R2aj value allows us to have good quality of prediction.

It is necessary before validating the conclusions of the analysis to verify the assumptions for the model of Ec 1 that corresponds to the best ANOVA that assumes that the residues are distributed normal, independent and with constant variance; failure to comply with any of these assumptions leads to erroneous conclusions. In Fig. 3a the predicted against the residuals are plotted, there it is observed that the points randomly fall vertically within a horizontal band, this behavior validates the assumption of constant variance, Fig. 3b the points of the execution number are plotted against the residues, here there is no trend in the points, then it is indicative that this assumption is fulfilled therefore it is concluded that there is independence of the residues and finally in Fig. 3c, the residuals are plotted on normal probabilistic paper can be observed that the points to some extent adhere to a line placed visually (it is not a regression line), it concludes that the model meets the assumption of normality of the wastes; In conclusion, the model meets the assumptions of normality, independence and constant variance of the wastes, so the conclusions reached regarding the optimum levels are correct and adequate for obtaining maximum compressive strength.

Fig. 4a shows the response surface plot as a result of adjusting the model of Eq. (1) to a set of points in the experimental zone, where you can observe the points to achieve the minimums (A ±, B- and C-) and maximums (A ±, B + and C +) coincide with the results of the optimal levels found with the previous analyzes. While Figure 4b shows the three-dimensional graph as a function of the three factors and the regions where it is possible to perform optimization treatments, finally the optimal points that maximizes compressive strength are: geopolymerizing material (MG) ratio with stabilized mining solid residue (SMW-S) by 60%, taking into account stabilization factors such as pH and molar ratio of stabilizer.

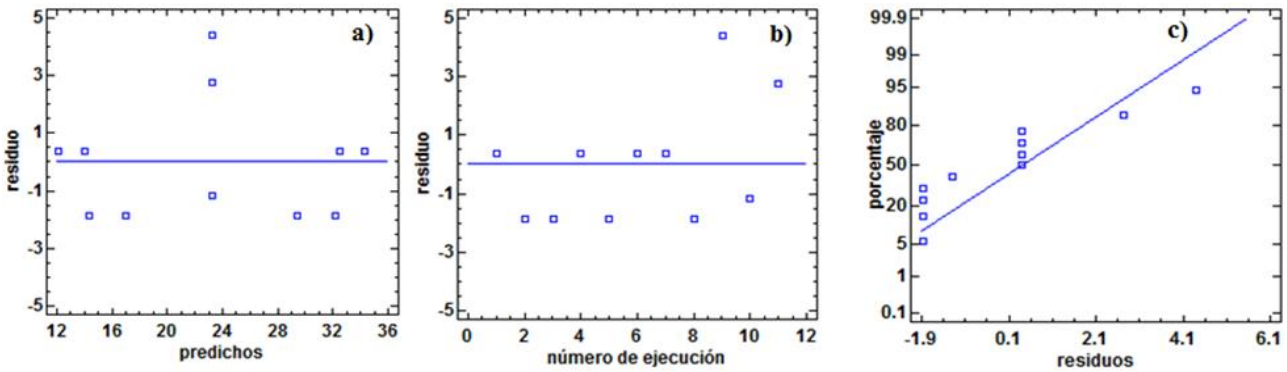

Fig. 3 Graphs of verification of assumptions a) constant variance of waste, b) independence of waste and c) normality of waste.

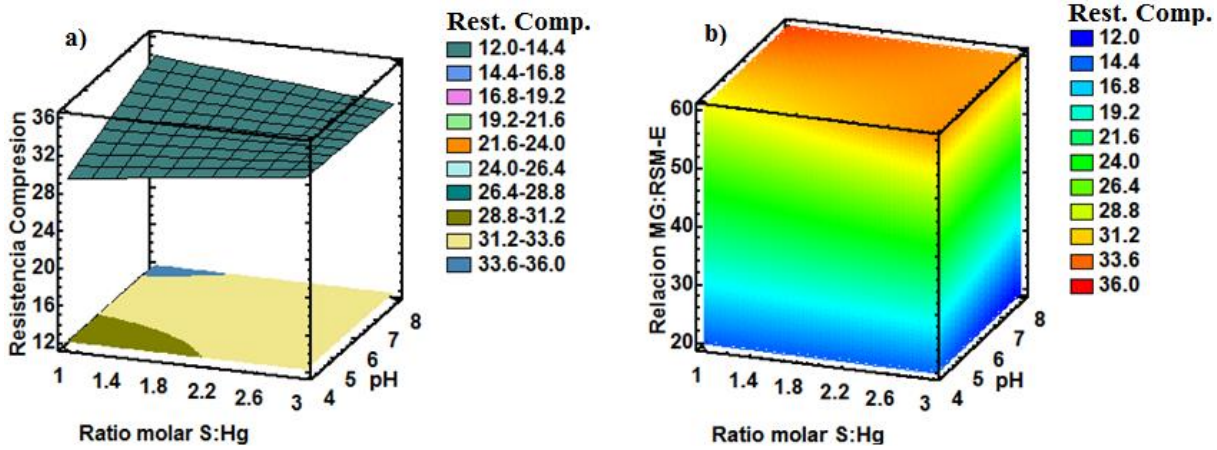

Fig. 4 Response Surface Graph for compressive strength at a MG: SMW-S ratio equal to 60%.

4. Conclusions

In the first phase of optimization of the geopolymer formulation with the raw material of 55% pumice stone and 45% metacaolin, a compressive strength of 41.67 MPa is achieved. Of the five concentrations evaluated for the alkaline solution, the 10M concentration proved to be adequate, resulting in a mechanical compression of 23.2MPa and with a molar ratio of Na2O/SiO2, SiO2/Al2O3 and H2O/Na2O at 0.24, 5.82 and 8.78 respectively. With this optimal geopolymeric composition, the stabilized mining solid waste from the Arequipa Region was immobilized. Of the eleven treatments performed, it turned out to be treatment seven that reached a value of 34.70MPa of mechanical compression at 28 days of cure, with the levels randomly designed according to factorial design (1: 1, 8 and 60) and the lowest values were in treatments 2 and 4, both with a value of 12.49 MPa. The optimum level determined was, in addition to the stabilized mining residue, the geopolymerizing material: stabilized mining residue (MG: SMW-S) ratio equal to 60%.

The variable that has a positive and important effect is the percentage of geopolymerizing material on SMW-S stabilized mining solid waste, reaching a value of 17.74 MPa with a percentage contribution of 70.83% followed by the interaction between AB variables with a percentage contribution of 10.79% negatively on the performance of compressive strength. It is concluded that the resistance to mechanical compression is governed by the percentage factor of geopolymerizing material, with respect to the mining waste, ratified by the ANOVA, with an R2 equal to 93.83 percent and an adjusted R2 of 84.58 percent indicating that the Model adequately explains the behavior of the data in the response variable. The variance analysis model meets the assumptions of verification of constant variance, independence and normality of the residues, so it adequately describes the hardening process measured by this property through compression resistance.

The concentration of mercury present in the mining waste of the Arequipa Region before the treatment was >225 and after the treatment with the geopolymer was < 0.001 in the TCLP test, a value that is below the national and international regulations. The heat treated materials are a source of aluminosilicates and in the presence of the alkaline activator, base with sodium silicate, gives a basic pH to the specimen formed with the mine residue, this basic pH is also responsible for this immobilization as well as the characteristics of the geopolymer formed, resulting very suitable for waste containing mercury, hazardous waste, such as solid mining waste, toxic waste considered harmful to human health and the environment

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Spatial Analysis of the Place: The Historical Journey of A School Community and the Construction of Identities

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Abstract: The article aimed to perform a spatial analysis of the place where an educational institution is inserted, located in the city of Taguatinga, Federal District. The article contextualized the formation of the school community with the growth and historical development of the city. The authors Cavalcanti (2017), Harvey (1999), Jatobá (2016); Leite and Barbato (2011) and Paviani (1999), based the discussions regarding the reflections related to the urban in the capitalist context and the management of urban space in the Federal District. Geography teaching was understood from the appropriation of the place, relating it to the daily lives of students. The reports of teachers, students and documentary analysis made it possible to conduct a geographical survey of the changes that occurred in the place and list the influence on the socioeconomic and cultural profile of the school community investigated. A significant part of the school community of the CED 04 educational institution consists of Vicente Pires' residents. The analysis came from the description of the place in which the school is inserted and the identification of the process of population expansion nearby. The result showed that the school community of the educational institution is a reflection of urban evolution.

Key words: spatial analysis, school community, geographical knowledge, urban expansion, place

1. Introduction

The article is part of the research carried out for the development of a master's thesis and was also presented at the XIII National Meeting of ENANPEGE – XIII ENANPEGE that had as its central theme, The Brazilian Geography in world science: production, circulation and appropriation of knowledge that was held in the city of São Paulo/Brazil in 2019.

The Educational Center 04 (CED 04) is inserted in the Administrative Region of Taguatinga. The school emerged in the 1970s, period in which the Federal District was in an accelerated process of population growth. For Marx, all social and economic phenomena must be analyzed from a historical vision, inserted in a social and material context produced by men, there are no absolute and eternal laws, everything can be transformed by man's action. So, the understanding of the place through the study of historical evolution enables social, political and economic analysis and the influence of capitalism on the transformations that occurred and the reflection of these actions on the lives of citizens.

In the first part of the article, a description of the place where the school is located will be made and the process of expansion of the region will be shown with the emergence of new demographic densities. At this moment, the historical characteristics of the school are mixed with the history of the city of Taguatinga.

In the continuity of the article, the demographic density that caused the increase in property prices, forcing the middle class to seek housing alternatives by occupying new public lands will be discussed. In this context, the emergence of Vicente Pires and other communities around the Educational Center 04 and the insertion of the new inhabitants of these regions in the daily life of the school community will be discussed. Then, the article will discuss the importance of daily

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life in the construction of geographic knowledge and in understanding spatiality.

In the final considerations it will be analyzed the spatial formation process of the Administrative Region of Taguatinga, its reflex on the formation of the school community of the institution and how these factors can influence the development of geographic knowledge.

2. Material and Methods

To the construction of the article, the documentary analysis of the Pedagogical Political Project (PPP) of the educational institution and the bibliographic reading of authors and reports of experiences of teachers working at school were used.

At first, the description of the space where the school is located was made, but the approach was not limited to a description of the place, it also showed the physical space as a place of experience, consisting of young people who give the place a meaning with all its characteristics, contradictions and perspectives and proved to be the process of expanding the place with the emergence of new demographic densities. At this moment, the historical characteristics of the school are mixed with the history of the city of Taguatinga. Who were the individuals who attended school during the period it was built? What was the socioeconomic profile of the families of the students of the institution at that time and what it is today? In the continuity of the investigation, the intense population growth of Taguatinga was discussed, as well as the real estate speculation and how this caused the rise in property prices, forcing the middle class to seek alternatives of housing, by occupying new public areas. In this context, it is presented the creation of Vicente Pires, as well as of other communities surrounding the school and the insertion of new inhabitants in the daily life of the school community. In the early 1990s the region continued to expand; and until the beginning of that decade, Vicente Pires was an area destined for rural production, because it is located in an urban region, it was called “green belt”. At that time, real estate speculation and land grabbing intensified, thus, the place went through an intense process of installment, originating several residential condominiums. Vicente Pires is today a authenticated Administrative Region, formed by several middle-class residential condominiums.

3. Results and Discussion

Since the mid-sixties of the last century, a reorganization of spatial configuration and new urban forms have been established (HARVEY) [1]. In Brazil, the new spatial configurations are characterized by population densities that originated urban centers and new cities, such as Brasilia, inaugurated in 1960. In other parts of the world, contemporary cities have many layers, they are superimposed on other existing ancient cities and gain new characteristics, but the marks of older civilizations can still be perceived through the urban, such phenomenon is the result of the chaotic urbanization caused by industrialization and modernizing speculation (HARVEY)[1]. The Federal District does not fit this model. The rectangle that houses the capital of the country was born of a political project and the strength and courage of pathfinders who moved to central Brazil, clearing and occupying the cerrado (savanna) biome. However, chaotic urbanization and modernizing speculation were also established in the region, the disorderly occupation of the space caused urban growth and the emergence of new cities that, by orbiting around the capital, were given the name of satellite cities today are identified as Administrative Regions. Taguatinga is one of these Administrative Regions.

Taguatinga, RA III of the Federal District, has its origin triggered due to the demographic expansion resulting from the construction of Brasilia, inaugurated in 1958. The government at that time distributed land parcels among the workers who came from various parts of Brazil to work on the construction of the new capital, therefore avoiding that they settle in Brasilia.

Initially Taguatinga was a farm with the same name, with urbanization limitations. According to Paviani:

> The great difficulty was selecting the land parcels receivers in the new city, since it was expected to attend only low-income workers and servers, and many slums were excluded from these formal criteria. Thus, the city is already born with the so-called "invasions" (Vila Dimas and Vila Matias), because there were many homeless people who did not adapt to the legality instituted by the distribution of land parcels, that is, the city forged social inequality ... the creation of Taguatinga was just a geographical change from their condition of excluded [2].

Over the years, RA[1]–III has become the point of arrival of Brazilians from different Regions of Brazil (Fig. 1) and, according to data from the Central Plateau Development Company [3], it is currently the third largest population in the District 222,598,000 inhabitants. Taguatinga is today one of the most prominent urban clusters in the Midwest region, considered the economic capital of the Federal District. Due to its economic importance, Taguatinga continued to expand in the following decades and, due to demographic pressure and housing demand, new Administrative Regions broke out throughout the Federal District, such as Ceilândia-RA IX, Samambaia-RA XII, Águas Claras-RA XX, and Vicente Pires-RA XXX, the last two, initially, were part of the spatial configuration of RA III.

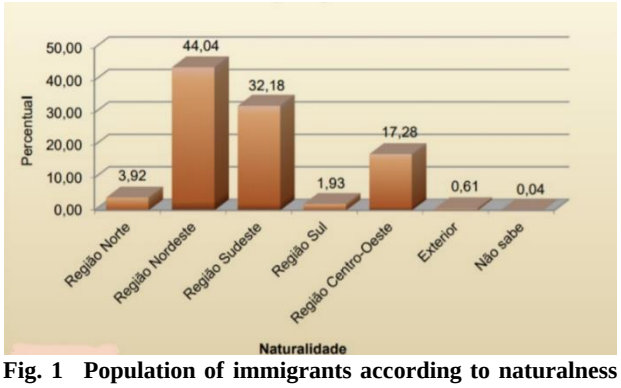

Fig. 1 Population of immigrants according to naturalness (Taguatinga - DF) [3].

In the 1980s, urban expansion in the Federal District continued to accelerate with significant demand for new housing. Due to high property prices, homelessness has become a serious social problem, which stimulated land grabbing. Jatobá (2016) [4] calls irregular land occupation urban territorial informality. For Jatobá:

> Urban territorial informality has generally been attributed to an alternative adopted by the poor to address their housing needs in the face of their exclusion from the formal housing market [...] [4].

In the Federal District, this dynamic is not exclusive practice of the poor people. In the last 30 years, the horizontal growth of the city shows the appearance of several condominiums located in noble public areas or in areas of environmental preservation (EPA), are the so-called "luxury condos".

Taguatinga houses many public education institutions, including Educational Center 04 (CED 04), opened in 1972. The school is located in the northern part of the city (QNG). The students of the school were local residents, because in the 1970s, the place was still lacking in infrastructure, such as absence of asphalt and this discouraged families from enrolling their children in the institution. Parents were looking for more schools in downtown Taguatinga.

Through reports, teachers working at the institution for almost two decades — they are also residents of the school's surroundings — said the emergence of the police battalion, banks, supermarkets and health posts made the area more attractive and contributed to the increase of enrollment in school. At that time, the residential courts of the QN [2] were considered periphery, so the socioeconomic profile of the students was characterized by people with low purchasing power.

From the 1990s, the area around educational center 04 (CED 04) has become an urban cluster. Vicente Pires, who is inserted in this context, was until the

[1] Administrative Region, a term that designates the former satellite cities of the Federal District. Currently, df consists of thirty-one RAs and are identified by numbers in Roman numerals.

[2] Quadra Norte G. Addresses of residential, commercial or industrial areas are abbreviated by letters.

beginning of that decade a rural production area, the so-called “green belt” of horticultural products. The families who lived there were not owners, but had government concession for a set time to reside and produce on the land. At that time, real estate speculation and land grabbing intensified, and agricultural land underwent an intense process of irregular installments, originating several residential condominiums. As Morales [5] write:

> In metropolises where demand for urban land is large and formal land supply is insufficient to serve it, informality is a strategy of owners and investors to offer lower quality merchandise to lower costs and increase rates of [5] (MORALES)

Fig. 2 Evolution of the Polygonal Urban Occupation of Taguatinga.

Vicente Pires since 2009 has been dismembered from Taguatinga and started to have its own administration, becoming the ADMINISTRATIVE Region RA – XXX, composed of middle-class people. A significant part of the students of the Educational Center 04 of Taguatinga are residents of Vicente Pires.

In addition to students considered middle class, they study in CED 04 students with lower purchasing power, some of them in significant poverty. The needy communities, in which many of the students are attended by governmental social programs, reside in the Settlement September 26, located in the surroundings of DF-097 (road), in Taguatinga, and in the Surrounding [3] region, more specifically Águas Lindas de Goiás. Both also emerged due to irregular occupations of public lands.

These communities live with violence, the difficulty of access to public transport, precariousness in relation to quality of life and lack of family structure. There are also students residing in nearby rural centers or in other Administrative Regions, such as Ceilândia and Samambaia.

To students who belong to the school community to have a better understanding of the empirical facts presented, it becomes necessary for them to develop a geographical look and learn to construct explanations of this reality lived by them on a daily basis (CAVALCANTI) [6]. To conceive this geographical look, one needs to understand what it is meant by geographical space and Municipalities of other Federation Units located near the Federal District and are part of RIDE — Integrated Development Region of the Federal District and Surroundings.

In an analysis of the urban changes resulting from the territorial expansion that occurred in the place where the school is located (Fig. 4), shows that this dynamic was also reflected in the school community formation of CED 04, currently it is characterized by students

[3] Municipalities of other Federation Units located near the Federal District and are part of RIDE - Integrated Development Region of the Federal District and Surroundings.

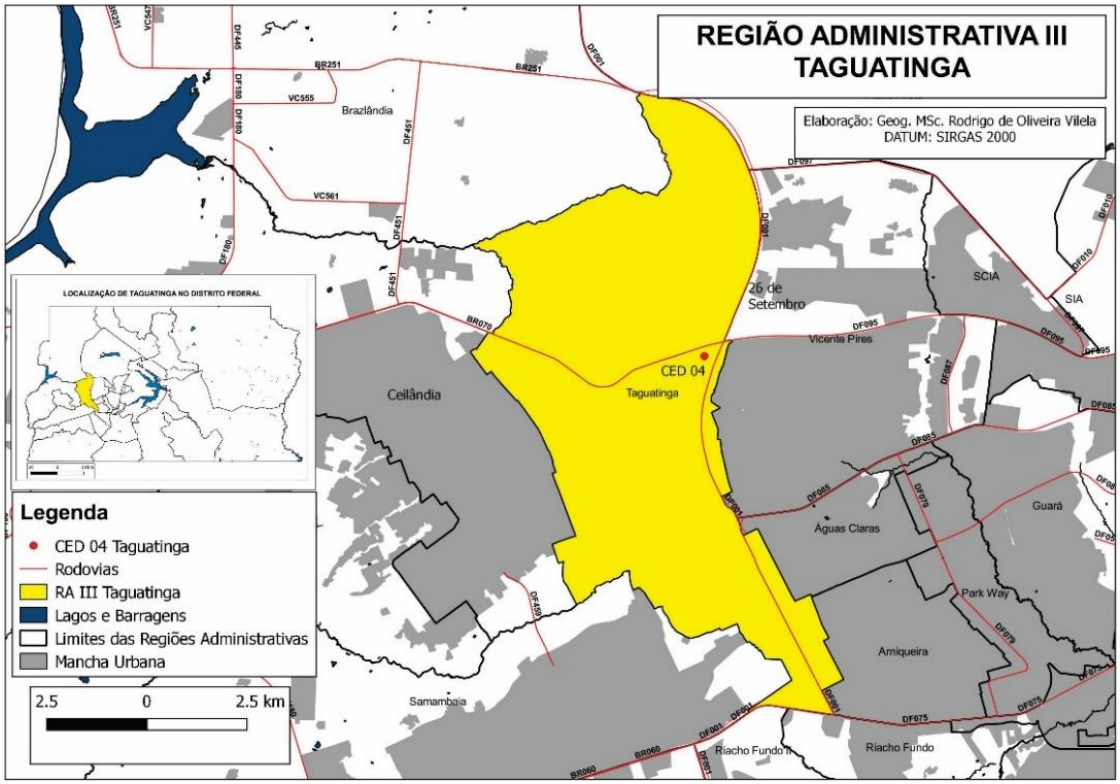

Fig. 3 Territorial configuration of Taguatinga – 2019.

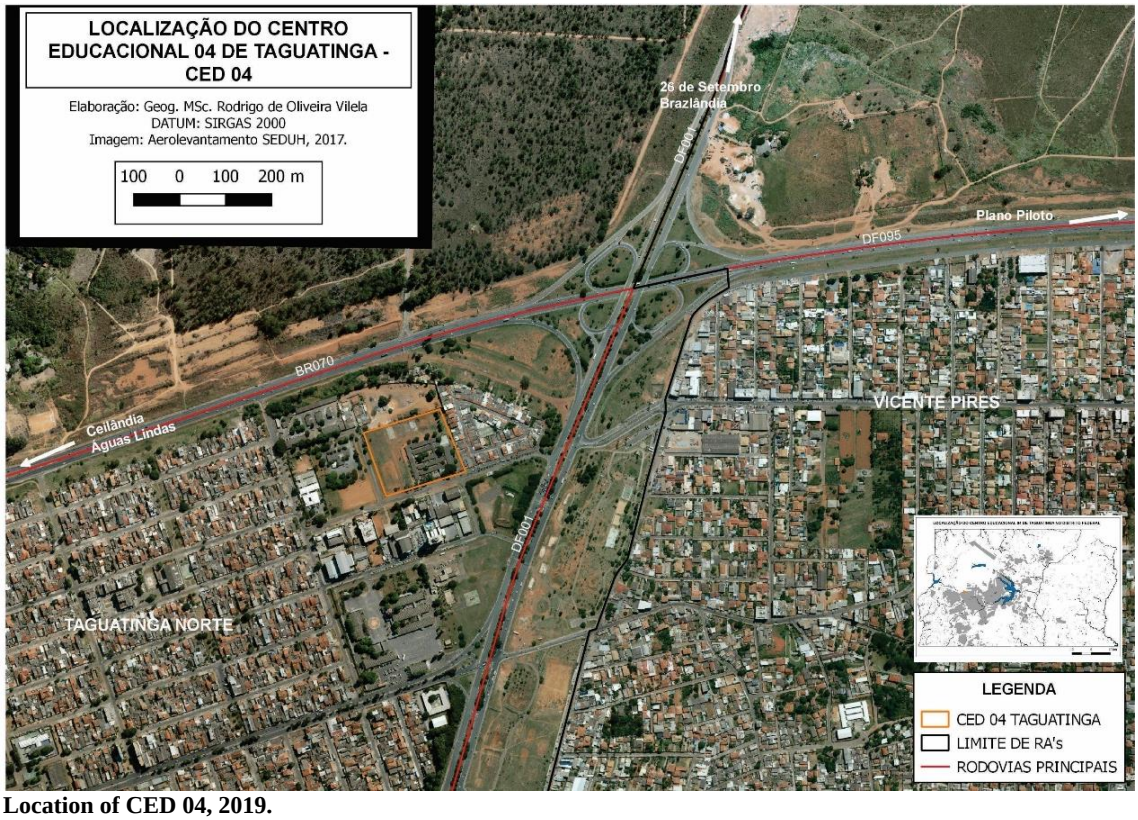

Fig. 4 Location of CED 04, 2019.

who live in different Administrative Regions of the Federal District and surrounding areas, under various socioeconomic conditions. The reasons that lead students from different RAs and around the surroundings to attend the school are various: some students seek the security they do not find in the community in which they live, young people around or in needy communities, live with daily violence; others consider that the quality of education is better than that from the schools on the peripheries in which they live; there are students who find the location of the institution more favorable — facilitates the displacement to work or internship — these students live in Ceilândia or Águas Lindas de Goiás (neighboring state) and need to work or do paid internship, both in Taguatinga and in Plano Piloto, Downtown Brasilia, and therefore making it easier for them to both study and work, without having problems with delay in both, attending a school with a more accessible location, as is the case of Taguatinga (Fig. 3).

Although students residing in Ceilândia, Fern and Águas Lindas de Goiás have less privileged economic situation than those who live in Taguatinga or Vicente Pires, they live daily in the same school and establish harmonious social relationships.

When analyzing the facts presented, it can be concluded that the CED 04 school community has undergone changes over the thirty-seven years of its existence. When it was inaugurated, the school community was made up of young people of less economically privileged class, since the school was considered from the periphery. Over time, it ceased to be a peripheral institution becoming a more accessible, compared to the new Administrative Regions that were emerging due to urban expansion. Currently, its student body is predominantly made up of middle-class students, despite having needy students, where some are even attended by government social programs.

When you want to work with school youth, it is important to understand that this group builds a type of social representation with different ways of acting and thinking, that this phase of life represents a period of construction of identity, establishing social relationships and projecting professional and emotional perspectives. Therefore, understanding youth is "as a representation of historical and social constructions related to chronological, cultural, identity, social and political aspects of the life development" [7].

In a spatial cutout of the reality of students studying in CED 04, the characterization of treated youth shows public school students living in the city, middle-class places and peripheries. The social representations in which these young people are anchored can be symbolized as follows: they live in a capitalist and predominantly urban society and carry with them social pretensions consistent with this model of society. To the youth to establish an affinity relationships with the school in which they study, it is necessary to identify and understand that the school will meet the future expectations of these young people beyond everyday life.

The human sciences, with an emphasis on Geography, are important because they extrapolate common sense, open the mind and reasoning to visions integrated with the world and allow a broader understanding of everyday life. Starting from this interpretation, Geography has the possibility to relate knowledge, its application in daily practice and to the perspectives available in urban life, in an attempt to provide a meaning of the school for these young people who social, professional and citizen training.

3.1 The Use of Daily Life to Mediate the Construction of Geographic Knowledge in the Teaching of Geography

Using daily life to mediate the construction of geographic knowledge is a possibility of geography, as a curricular component of high school. From this understanding, the teaching of Geography returns to its action for the student in his learning process, thinking,

reflecting on the place of his/her experiences and regarding the application of the geographic knowledge acquired. Therefore, understanding the historical journey of your school community provides students to build their identity related to their life experiences.

The analysis of geography teaching in the context of the place in observance of the CED 04 school community aimed to prove the relevance of geography teaching, through the reports of interactions in their spaces experienced, in order to provide the understanding of the transformations that occurred, emphasizing the importance of the geographic place experienced, regarding the notions of belonging as a means of awareness of social evolution and urban expansion.

Knowledge sharing gives meaning to the understanding of urban dynamics, allows the conscious search for collective objectives, judged desirable in its reality, through methodological and critical school work in the teaching of geography. Corroborating Leite and Barbado [8] (2011):

> The considerations about the place become important because it represents the opportunity of legitimation of the subjects, their experiences, their views, their knowledge. In this sense, an important role of education is to instrument the actors involved in the context of teaching-learning relationships, to understand that all human beings have a knowledge based on their own experiences. And that this constitutes a significant mediation in the process of knowledge construction [8].

In this context, teaching geography through the historical journey of the student's daily place, gives it both a new dimension and meaning; outlines the relationship between the known, the very, the place and the social memory of the community; in addition, it aggregates values of different knowledge aimed at building participating citizens in critical potential.

Understanding the place constituted in its living space emphasizes spatial knowledge, allows the use of different pedagogical practices listed in the knowledge proper to the school community. This practice gives the teacher to give meaning to reality, which has a direct relationship with the formation of citizenship.

Therefore, by exploring the content of the knowledge of the group, it will mediate this knowledge with geographical concepts, enabling the geographical analysis of the student in the face of this problematic situation to understand and understand the reality of the place experienced. According to Leite and Barbado [8] (2011):

> Notably when schooling is based on the knowledge of local and regional histories and the expansion of a type of knowledge, which starts from teaching and learning practices of communities, valuing them. This fact points to the need to move towards dialogue between successful pedagogical practices so far and the creation of new ways of mediating [8].

Thus, education is a mediator of the production of meanings and the construction of reality, configuring different forms of innovation in geography learning.

4. Conclusion

The discussion presented in the article was developed from the analysis of the spatial development of the place and the construction of the identity of the school community of a public school of the Federal District. The historical construction of the school is related to the growth and development of the Administrative Region in which it is inserted, as well as the formation of its school community in which at first because it is a region on the outskirts of the Federal District and lacking infrastructure, the local community itself avoided enrolling its children in the institution, over time, the growth and development of Taguatinga and the emergence of new peripheries made administrative region III a major economic hub of the Federal District, thus making the school more attractive to students from other locations. Therefore, the profile of the public attended by the institution has become more diverse and school more attractive for students living in other locations.

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Studying the Process of Dispersing Gamma Radiation, Radioactive Gas (Radon, Thoron) in Rare Earth Mines

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Abstract: In order to serve the national industrialization and modernization process, many mineral mines have been promoted and exploited to serve socio-economic development, including mineral deposits. radiation. When the exploration and exploitation process is carried out, it is necessary to have the impact of artificial factors to upset the rock layers, breaking the natural position of the ore bodies, increasing the dispersion process, leaching… makes the process of dispersing radioactive substances into the environment more and more powerful and complicated. Studying theoretical models and empirical surveys shed light on the spread of radionuclides emitting gamma radiation, radioactive radon, thoron on rare earth ore bodies containing radioactivity. Survey results on rare earth ore bodies cause gamma radiation dose rate with amplitude 0.6 ÷ 7.7 μSv/h, radon concentration has amplitude (30 ÷ 45).10^3 Bq/m^3, concentration degree thoron amplitude (45 ÷ 70).10^3 Bq/m^3.

Key words: radon, thoron, gamma radiation, radioactivity, rare earth, dispersal, environment

1. Introduction

Our country has abundant mineral resources, including radioactive ore mines (uranium in sandstone, Trung Nong Son coal) and many types of radioactive minerals (coastal placer, rare earths Nam Xe, Dong Pao, Muong Hum, Sin Quyen copper, uranium phosphate in Binh Duong).

Our country belongs to the tropical region, the climate is hot, humid and rainy, the surface soil is affected by strong weathering and weathering. Therefore, most of the ore mines in general and the radioactive ore mines in particular are in the form of "hidden" ores, the ore bodies are often buried under unconsolidated cover.

In many regions of our country such as Lai Chau, Lao Cai and Yen Bai, there are rare earth mines with large reserves of medium and large mines in the world. In rare earth ores containing radioactive substances Th, U, this is the cause of gamma radiation, high radioactive radiation abnormalities in the area [1].

The mineral mines themselves have high radioactive content causing radioactive anomalies with the radiation dose rate of tens of μSv.h^{-1}, the concentration of radioactive gases hundreds, thousands of Bq.m^{-3} in the area they exist. When exploring, exploiting, people carry out drilling, digging trenches, furnaces, opening fields... making soil cover and vegetation cover removed, ores excavated, collected and enriched. All these activities increase the natural radiation field (increasing gamma radiation, radioactive gas concentration...) at the mine and spreading the content of radioactive substances to the surrounding environment causing harmful impact to the environment and human health.

In the content of the article, the author presents the research results of the process of dispersing radionuclides emitting gamma radiation, radioactive gas from the body of rare earth ores containing

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radioactivity to the environment and proposing solutions to minimize mitigation.

2. Radon Emission to the Environment from Rare Earth Ore Bodies

The rare earth ores of our country are usually in the form of pockets, loaves, vessels or lenses. The content of total rare earth oxides TR_2O_3 ranges from a few percent to over 30%, averaging 10%. The content of roughri in weathered rare earths is 0.0199% to 0.0441% ThO_2, in rare earths original ore is 0.0087% to 0.0204% ThO_2, the uranium content in rare earths is from 0.001% to 0.023% U_3O_8 [1].

The ore body model has a width of tens of meters, a length of hundreds of meters, an average thickness of 3-4 m, a maximum of 7 m can be considered as a horizontal layer of ore lasting indefinitely.

Here we calculate the distribution of radioactive gas concentration in the two layer environment: infinite horizontal, the second layer is the radioactive ore layer below with the parameters: radioactive content q_2, concentration radioactive gas N_2, density ρ_2, pore coefficient η_2, diffusion coefficient D_2, a_{02} - amount of free eman released into $1cm^3$ stone in 1 second, ($Bq/cm^3.s$), emanization coefficient K^{e2} . The first layer is the top layer of thickness h and parameters N_1, ρ_1, η_1, D_1, K_{e1} (Fig. 1).

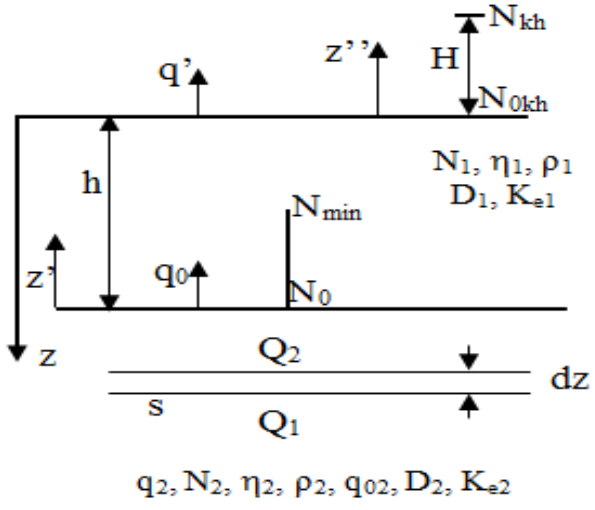


Fig. 1 Model of radioactive gas concentration distribution in the ore layer.

The concentration of radioactive gas N in an environment with pore η varies only in the z-axis direction. The differential equation for equilibrium of radioactive gas in the dx layer has the following form:

$$\frac{\partial}{\partial t}(N\eta Sdz) = Q_1 - Q_2 + a_0 Sdz - \lambda N\eta Sdz \quad (1)$$

In which: radioactive gas flows through the area S of class dz

$$Q = DSdN/dz + vN\eta S \quad (2)$$

$$a_0 = N_\infty \lambda = K_e q \rho \lambda .3.7.10^{10}. \quad (3)$$

The distribution of radioactive gas concentration according to the sampling depth z is determined by solving the differential Eq. (1) [4, 12].

2.1 The Concentration of Radioactive Gas in the Covered Soil (the First Layer When z <h)

$$N_1(h-z) = N_0 e^{m_1(h-z)} \frac{sh(n_1 z)}{sh(n_1 h)} \quad (4)$$

2.2 The Concentration of Radioactive Gas in the Ore Layer (Second Layer z > h)

$$N_2(z) = N_{2\infty}[1 - \frac{e^{-(n_2+m_2)(z-h)}}{1 + \frac{D_2(n_2+m_2)}{D_1 n_1[(cth(n_1 h) - \frac{m_1}{n_1})]}}] \quad (5)$$

In which:

$$N_0 = N_{2\infty} \frac{1}{1 + \frac{D_1 n_1}{D_2(n_2+m_2)}[cth(n_1 h) - \frac{m_1}{n_1}]}$$

N_0 is the concentration of radioactive gas at the boundary of the first and second layers.

$$m_i = \frac{v\eta_i}{2D_i}; \; n_i = \sqrt{m_i^2 + \frac{\lambda \eta_i}{D_i}}$$

When $h \to \infty$, the formula (4) has the form:

$$N_1(h-z) = N_0 e^{-(n-m)(h-z)} \quad (6)$$

If r = h - z is the distance that the concentration of radioactive gas decreases from the value N_0 to the value of N_{min} (the minimum value that the radioactive gas device can reliably determine), then we determine:

$$r = 2{,}3\lg\frac{N_0}{N_{\min}}\frac{1}{\sqrt{(\frac{v}{2D^*})^2+\frac{\lambda}{D^*}}-\frac{v}{2D^*}} \quad (7)$$

In which:

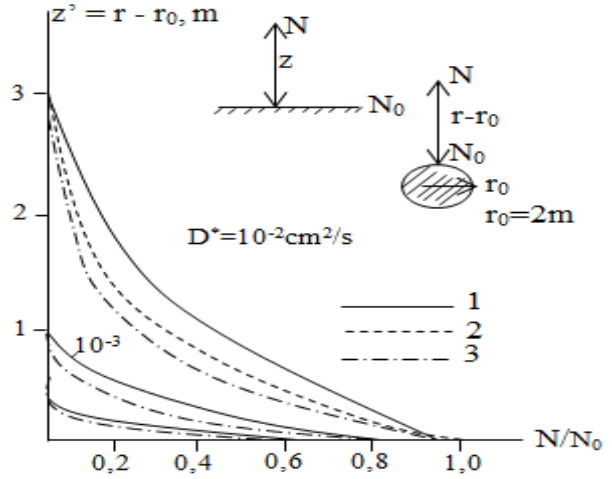
v - convection rate of radioactive gas,

D^* - apparent diffusion coefficient $D^* = D/\eta$.

Eq. (7) is used to assess the depth of the radioactive gas method.

Theoretical calculations indicate that the propagation of radon from the source to the ground and the depth of the radioactive gas method depend on the parameters D* and v.

The results of calculating the radon concentration distribution on the ore bodies of different shapes (Fig. 2) show that the decrease in the value of the concentration when away from the source mainly depends on the diffusion coefficient D* which little depends on the type of ore body, if the coating thickness does not exceed the ore body diameter [4].



1- The infinite ore layer

2. The ore body has a horizontal cylinder shape

3. The ore body is in the form of a sphere

Fig. 2 Rn concentration distribution on different shape ore bodies.

Due to the short half-life ($T_{1/2}$ = 54.5 seconds), the depth of the radioactive gas method for thoron is only about 2-4 cm. This means that the depth of the thoron method corresponds to the depth of gas sampling [4].

2.3 The Concentration of Radioactive Gas in the Air Environment

From the model of ore layers and soil cover as shown in Fig. 1, we can calculate the concentration of radioactive gas in the air above ground $N_{kh}(0)$ and at height H from ground $N_{kh}(H)$.

$$N_{kh}(0) = N_\infty\eta\sqrt{\frac{D^*}{A}} \quad (8)$$

$$N_{kh}(H) = N_{kh}(0)e^{-\sqrt{\frac{\lambda}{A}}H} \quad (9)$$

in which: A - ground air stirring coefficient is 10^3 cm^2/s while H = 30-50m then A = 10^4-10^5 cm^2/s.

Theoretically and empirically can determine the concentration of radon in air close to the ground thousands of times smaller than its value N_∞ in rocky environment. In the absence of wind, the radon concentration in the atmosphere decreases slowly with altitude; thoron concentration decreases very quickly and completely eliminates at a distance not exceeding 10cm from the ground [1-4].

3. Emission of Gamma Radiation to the Environment from Rare Earth Ore Bodies

In the process of exploration and exploitation of rare earth ores, it is necessary to carry out the work of drilling, excavating, making roads… All of these processes cause the surface rock to be disturbed, increasing the discovering the ore body, making gamma radiation field from the ore body easily spread into the environment. For gamma radiation field, there are two main emission mechanisms:

- Gamma radiation has a large puncture ability, so in each project, each trenching area, the seams become a source of radioactivity exposed on the surface, gamma

radiation field easily penetrates in the atmosphere far away from its source.

- The process of digging, trenching and drilling will bring to the surface a large amount of rocky soil containing radioactive ores, these radioactive substances dissolve on the one hand, and move mechanically on the other topographic conditions go far from their original locations, causing widespread pollution in many places.

To see the level of distribution of gamma radiation in the environment as well as the ability of the influence of gamma radiation to each different position in the air environment. The following gamma radiation theory is calculated on a rare earth ore block model with an average uranium content of 0.01% typical U3O8 [5-8, 11]. The radioactive ore body in this case is considered to be horizontal ore body, finite in size. The intensity of gamma radiation caused on the ore body at each position relative to the ore body boundary is calculated as follows:

The source of gamma radiation here is considered to be a finite disk-shaped source with radius R right on the ground. The medium that determines gamma radiation intensity is the air environment (Fig. 3).

The intensity of gamma radiation emitted by the source is limited in the ground, the radius r is calculated as follows: Considering the intensity of gamma radiation of the source element, the volume dm has the volume dV in the radioactive disk. The source strength of the dI element is calculated as follows:

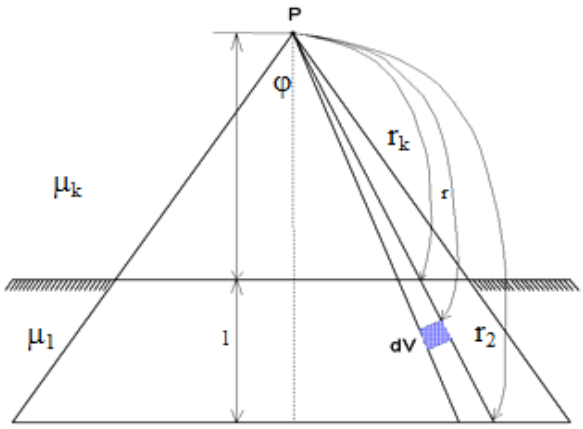


Fig. 3 Gamma radiation field of finite size source.

$$dI = K\frac{dm}{r^2}e^{-\mu_1(r-r_k)-\mu_k r_k} = KQ\rho e^{-\mu_1(r-r_k)-\mu_k r_k}.\sin\psi.d\psi.dr.d\varphi \quad (8)$$

Calculate the integral by the finite disk volume:

If: $r_k = H\sec\psi$

$r_2 = (H+1)\sec\psi$.

$$I = KQ\rho\int_0^{2\Pi}\int_{r_k}^{r_2}\int_0^{\psi_0} e^{-\mu_1(r-r_k)-\mu_k r_k}.\sin\psi.d\psi.dr.d\varphi$$

$$= \frac{2\pi KQ\rho}{\mu_1}\int_0^{\psi_0} e^{-\mu_k H\sec\psi}.\sin\psi d\psi.\int_0^{\psi_0} e^{-[\mu_1 l+\mu_k H]\sec\psi}\sin\psi d\psi \quad (9)$$

$\int_0^{\psi_0} e^{-x\sec\psi}.\sin\psi.d\psi$ is represented by the Kinθ(x) function.

The given Kin function value [4].

$$\int_0^{\psi_0} e^{-x\sec\psi}.\sin\psi.d\psi = \Phi(x) - \cos\psi_0\Phi(x\sec\psi_0) \quad (10)$$

In which:

$$\Phi(x) = \int_0^{\pi/2} e^{-x\sec\psi}.\sin\psi.d\psi = \int_0^{\pi/2} e^{-x} - x\int_x^{\infty} e^{-u}.u^{-1}.du \quad (u=x.\sec\psi) \quad (11)$$

Calculated results:

$$I = \frac{2\pi KQ\rho}{\mu_1}\{\Phi(\mu_k H) - \cos\psi_0.\Phi(\mu_k H.\sec\psi_0) - \Phi(\mu_1 l + \mu_k H) + \cos\psi_0\Phi[(\mu_1 l + \mu_k H)\sec\psi_0 l]\} \quad (12)$$

In which: $Cos\psi_0 = \frac{H}{\sqrt{R^2+H^2}}$

Consider the particular cases of formula (12) above.

3.1 Semi-infinite Radiation Space, Intensity Measurement Taken at the Ground

Then we have:

$l \to \infty$; $R \to \infty$; $\psi_0 \to \pi/2$; $H \to 0$

$\psi_0 \to \pi/2$; $R \to \infty$; $l \to \infty$; $H \to 0$

Then $\cos\psi_0 \to 0$; $\Phi(\mu_k H) \to l$;

$\Phi(\mu_1+\mu_k H) \to 0$

We have: $$I_\infty(0) = \frac{2\pi KQ\rho}{\mu_1} \quad (13)$$

This is the general formula for calculating the gamma radiation dose right on the surface of the ore body, which lasts infinitely long, thick enough to saturate gamma rays.

3.2 When the Intensity Measurement Is Made at Position H

$$I_\infty(H) = \frac{2\pi KQ\rho}{\mu_1}\Phi(\mu_k H) = I_\infty(0).\Phi(\mu_k H) \quad (14)$$

This is the formula for calculating the gamma dose rate in air.

In the above formulas:

I - Gamma radiation dose rate (also called gamma intensity, μR/h);

K - is the gamma radiation constant; $K_{Ra} = 9{,}1.10^9$; $K_U = 3{,}15.10^3$; $K_{Th} = 1{,}35.10^3$ (K's units are $\mu R/h.cm^2/g$);

Q - is the content of radioisotope calculated as g/g rock;

ρ - is the source density, g / cm3;

μ -is the weakening coefficient of gamma radiation, cm^{-1}. The weakening factor μ depends on the environment.

Table 1 shows the coefficients that weaken the intensity of gamma radiation by empirical literature [9, 10].

Table 1 Coefficient of weakening gamma intensity of volumetric source.

Ore type	Measurement type	Detector for recording gamma intensity (Ig)	Energy threshold (MeV)	$\mu_m = \mu/\rho$, cm^2/g		
				Rock	Water	Air
Uranium ore	Integral	CU-19Γ NaI (Tl)	- 0.035	0.037 0.028	-	- 0.025
	Differential	NaI (Tl)	1.05-1.35 1.35-1.55 1.65-1.85 2.05-2.65	0.034 0.034 0.034 0.035	- 0.036 0.037 0.038	- 0.032 0.033 0.034
Thorium ore	Integral	CU-19Γ NaI (Tl)	- 0.035	0.034 0.021	- 0.024	- 0.022
	Differential	NaI (Tl)	1.05-1.35 1.35-1.55 1.65-1.85 2.05-2.65 2.4-2.8	0.032 0.032 0.033 0.035 0.037	- 0.032 0.034 0.035 0.037	- 0.029 0.030 0.031 0.033

From formulas (13) and (14) above, it is possible to see the decrease in gamma dose rate at different locations in the air environment. Calculate the gamma dose rate on the ore-containing rock mass as follows: The device used to measure the gamma dose rate is a device with NaI crystal type detector (Tl), the size of the ore-containing rock mass as specified above, that is enough saturation gamma ray. We calculate the gamma dose rate due to the rare earth uranium-containing rock mass at different locations compared to the ore body boundary. The mass weakening coefficient of gamma dose rate in rocky soil for ore containing U is equal to 0.028; The mass weakening coefficient of the gamma dose rate in the air for ore containing U is equal to 0.025 (according to the above experimental table for NaI crystal type (Tl) for ore containing U), the density of rock in the body the ore is 2.2 $g.cm^{-3}$ and the air density is 0.03 $g.cm^{-3}$. The values of Kin function are taken in the lookup table in the radioactive exploration curriculum [4]. The result of calculating gamma radiation dose rate at different locations in the air for rock mass is shown in Fig. 4.

The graph in Fig. 4 shows: With the ore body content equivalent to 0.01% U_3O_8, they cause gamma dose rate on the ground 52 $\mu R.h^{-1}$. At one metter, the gamma dose rate is about 40 $\mu R.h^{-1}$ (reduced by 23% compared

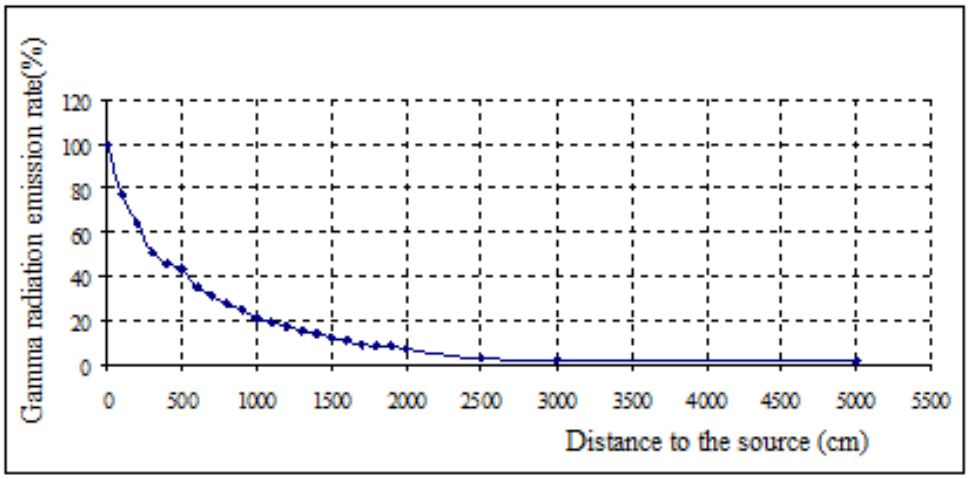


Fig. 4 Gamma radiation dose rate drop on rare earth bodies containing radioactive material.

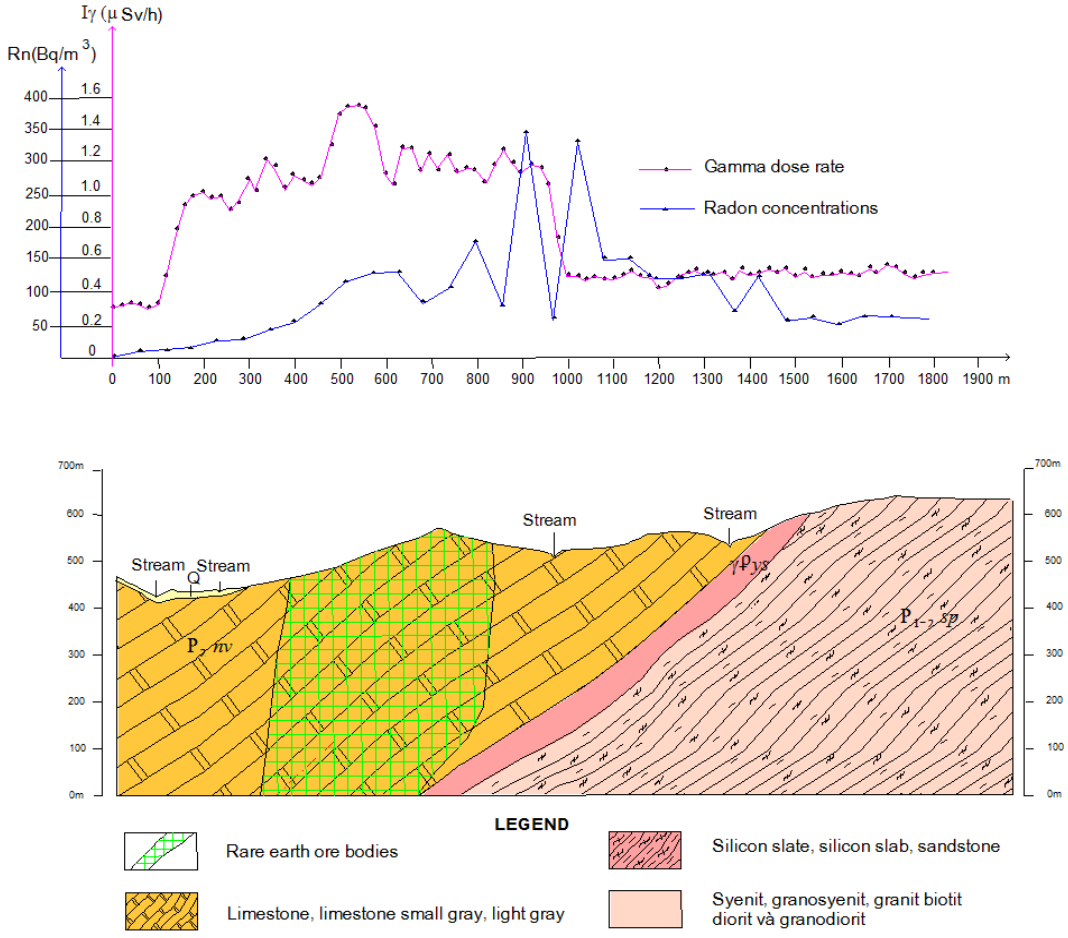


Fig. 5 Gamma dose rate distribution and radon gas on rare earth ore bodies.

to the ground). At 25 m from the ore body boundary, the remaining gamma dose rate is about 1.3 $\mu R.h^{-1}$ (2.5% of the radiation rate compared to the ore body boundary). When away from the boundary of the ore body 33 m, the gamma dose rate is ~ 1$\mu R.h^{-1}$ (0.01 $\mu Sv.h^{-1}$) within the sensitivity range of the current dosimeters. In other words, for ore bodies with a concentration of 0.01% U_3O_8, the effect of gamma dose

rate in the air environment is caused by them at a distance of at least 30 m, that is the influence of the source of rock and soil containing ore from the ditch works is raised to about 50 $\mu R.h^{-1}$ (equivalent to the external projection dose of about 5 $mSv.year^{-1}$), far from the area of rocky soil containing ore 30 m, the dose rate is not significantly affected. (0.1 $mSv.year^{-1}$). For ore bodies, the radioactive content is greater than the impact ability will be greater, but far from the ore body, about 50 m, this influence level is considered insignificant.

4. Results and Discussion

The mechanism and level of radioactive nuclear dispersion of gamma radiation and radioactive gas to the environment were studied due to the process of exploration and exploitation of rare earth ores containing radioactivity. Formulating a theoretical model of gamma radiation emission and radioactive gas emission of rare earth ore on the basis of selection of typical parameters, suitable to the actual conditions of exploration and mining rare earth ore mine contains radioactivity. The research results draw the following remarks:

- Gamma radiation field emitted from rocky soil containing radioactive ores that are able to penetrate in the air to several tens of meters (depending on the ore content). The ore body contains radioactive gamma radiation intensity depending on the content of radioactive substances and the materials shielding them.
- When carrying out the work of trenching, seaming or in direct contact with the ore bodies containing high radioactive content, it is necessary to apply mitigation measures by means of shielding or avoiding direct contact with the source (body ore).
- For ore bodies of industrial content, it is necessary to apply a reasonable working regime to workers directly executing excavation works and technicians when collecting data.
- Due to the long lifetime, radon gas has the ability to spread far in the air and is the subject of radiation dose affecting human health and the environment.
- For construction officials who need to pay special attention to the irradiation caused by radon gas, practical measurements should be made to make specific recommendations in each case.
- Before going down to the trenches, the furnace should have ventilation measures to reduce the radon concentration in the works.

5. Conclusion

The article has stated the mechanism of releasing gamma radiation and radioactive gas to the environment in radioactive mineral exploration and mining.

For the model of dispersion of radionuclides emitting gamma radiation in the air environment of rocky soil containing radioactive ore taken from excavation works potentially affected within a radius of < 50 m (according to calculation model), the closer the source is, the greater the level and likelihood of influence, especially in areas where the ore body has industrial content (> 0.05% U_3O_8).

With the theoretical calculation results the decline of radioactive gas in the air has shown that radon concentration decreases slowly in the air environment, on the other hand due to the long half-life, radon gas when released into the air environment usually exists for a long time and moves very far from the source, especially the terrain valleys and the wind blowing in fixed directions. Thoron gas escapes into the environment very quickly, usually very rarely at a height of several meters, on the other hand, the short half-life (54.5 s) should exist not long in the environment and move not far from the transmitter source region.

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