The Study of the Physical and Chemical Behavior of Activated Carbon in the Permeable Concrete for Light Traffic Paving

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Abstract

The water treatment processes in which microorganisms act are margin filtration, slow filtration and biological activated carbon (CAB) [2]. For this research, a study of permeable concrete with the addition of 2% activated carbon for light traffic paving was performed. The objective of this research is to identify the feasibility of using this concrete so that filtered water can reach at least the basic sanitation networks, with a better quality to be treated. For this, characterizations of the quality of the concrete component *materials were made with a novelty, using the fine aggregate (sand). After the characterizations, the permeable concrete traces with mechanical strength of 30MPa were made. Dosing analyzes followed with molding, curing and rupture of concrete specimens. The results of the arithmetic mean of the axial compression of conventional concrete at 28 days were 34.2 MPa and the concrete with the addition of activated carbon was 32.2 MPa, reaching the expectations of strength. Complementary experiments were performed for the quality of the water filtered by the CP's, the pH, the alkalinity and the chlorine content were analyzed. The pH of the conventional concrete found was 7.6 and the concrete with the addition of activated carbon was between 7.2 and 6.8, which may be the best result found.*

Keywords: Activated carbon. Permeable concrete. Water quality.

1 - INTRODUCTION

The study of new advanced technologies for wastewater treatment has been intensified due to the growing public concern about health and environmental effects [1]. [2] Biological treatment of drinking water aims to reduce water instability through oxidation of biodegradable organic matter and inorganic compounds present in reduced form such as iron, manganese, sulfur and ammonia. Examples of water treatment processes in which microorganisms act are margin filtration, slow filtration and biological activated carbon (CAB).

Activated charcoal stands out due to its high purifying power. This feature is related to the high degree of porosity, the extensive internal surface area, as well as the variety of functional groups on its surface [3].

For the most part, construction planning in large cities takes more account of building shading and vehicle traffic. Not much attention is given to the management of rainwater and cloacal sewage, which is disposed directly into water bodies without any treatment. Many aspects end up contributing to poor urban management of rainwater such as: lack of knowledge of the population and professionals in the development of drainage systems; ignorance of the whole in relation to the river basin; and speculation by large companies, which profit greatly from channeling [4].

[5] Public actions for the solution of these problems in Brazil are mostly focused only on structural measures. The solutions usually found by the public authorities have been drainage networks, which simply transfer the flood from one point to another, without evaluating the real benefits of the work.

Therefore, permeable concrete has been a viable solution because it is simple, inexpensive and fast to apply. The use of this type of pavement can eliminate the need for costly measures to control stormwater runoff, such as retention basins, ditches and ponds. It can be used in places such as low-volume pavements, such as sidewalks, pool decks, squares and parking lots [6].

By definition, permeable concrete is a concrete that has a void content of 15 to 25% of its total, using little or no fine aggregate in its paste, just enough to maintain cohesion between coarse aggregates and porosity. . Due to this low amount of fine aggregate, as a function of porosity, it has a low compressive strength, somewhere around 5 to 15 MPa. This way, it has been used for light traffic places, such as: parking lots, driveways, sidewalks and more [7].

Given this scenario, this paper developed a research of permeable concrete with partial addition and /

or replacement of cement in activated carbon, with the purpose of promoting the return of clean rainwater to the groundwater through filtration. The study of this composition also studies not only the physical performance but also the chemical behavior of this material.

2. LITERATURE REVIEW

2.1 Raw Material for Activated Coal Production.

Specifically, there is no raw material for activated carbon. It can be produced from the combustion of wood, bones, bark, starch, rubber, coal and also synthetic polymers such as thermoplastics, thermosets and etc. What makes it active is the process of hydration of the raw material as carbonization without the matter turning to ashes.

The following figure 1 shows the raw material used for the production of activated carbon in this research.

Figure 1 - Saw dust and / or sawdust as raw material of activated charcoal for this research.
Source: Authors (2019).

The activated carbon production process takes place in two main stages, namely: carbonization and activation that can be both physical and chemical.

[8] Carbonization consists of a thermal decomposition of carbonaceous material, eliminating non-carbonic species and producing a fixed carbon mass with a rudimentary porous structure, where many extremely thin, closed pores are formed at this stage.

The purpose of activation is to increase the diameter of these pores and create new ones [9]. Due to the conditions of carbonization, activation and source material used in its production, activated carbon will have different characteristics in its structure, texture and surface properties. Along with its highly developed internal surface area and porosity, pore size distribution is one of the most important properties that influence the adsorption process [10].

2.2 Activated Charcoal and its Utilities.

Coal was already described by various ancient peoples, such as Egyptians and Greeks, and their effects in combating intoxication, and were also known to the American Indians. In the 19th century, the first reports of public experimentation appeared, demonstrating their ability to neutralize potentially lethal poisons [11].

Activated carbon is a carbonaceous material, characterized by its highly developed surface area and porosity, which gives it the ability to adsorb molecules in both liquid and gaseous phases [12]. It is an adsorbent of industrial interest and its applications include water treatment, sugar refining, precious metal recovery, air deodorization, etc [13].

[14] The use of activated charcoal is now considered one of the most efficient treatments in cases of poisoning, especially when relief is given within 5 hours after poisoning. Activated carbon adsorbs the toxic substance and decreases the amount available for absorption by the digestive system. Its side effects are minimal. Toxic substances adsorbed in the pores are eliminated with charcoal through the faeces. Therapeutic doses vary according to patient size and weight, in addition to the substance to be adsorbed.

Figure 2 below shows the raw material with the combustion process performed.

Figure 2 - Combustion of the raw material for the production of activated charcoal.
Source: Authors (2019).

3. MATERIALS AND METHODS

3.1 Activated Coal Production

The method used for the production of activated charcoal does not meet any technical standard, since there is no specialized technical prescription for the manufacture of this material. But, compared to the countless researches tirelessly carried out on the production of this material, it was possible to attend to methods from which centenary people made this manufacture, as well as various methodologies adapted as equipment was updated.

For this research, the sawdust combustion muffle was used to transform the raw material into activated charcoal. The material for combustion, the sawdust, was donated by Madeireira Alicerce, located in the south central area of the city of Manaus.

Muffle is equipment used for the calcination of substances of which it is internally coated with a refractory material that resembles an oven which can reach high temperatures (1400ºC) and which also resembles a greenhouse because it has an external metallic coating. accompanied with a thermostat for temperature control.

The combustion of the sawdust in the muffle was performed with the thermostat set at 800ºC, so the raw material would reach the goal and not become ashes. Porcelain containers with a reasonable amount of between 5g and 10g were also used for burning the sawdust, so the container would not be so full. Figure 3 below shows the production of activated charcoal by combustion of sawdust inside the open muffle porcelain containers prior to the combustion process.

Figure 3 - Activated charcoal production by sawdust combustion inside porcelain containers.
Source: Authors (2019).

The equipment (the muffle) for the combustion of the raw material (the sawdust) is located in Unit 9 of the Centro Universitário do Norte (UNINORTE), in the Metallography laboratory.

After the natural cooling of the charred material, it went through the mortar kneading process with the aid of the gravel hand and then passed through the 75µm mesh sieve (nº200) for further characterization analyzes.

3.2 Materials Used In Concrete Design.

3.2.1 The Water

The water used in this research for the production of concrete was distilled type produced in the Chemistry laboratory, also located in UNINORTE Unit 9 and taken to Unit 11, of the same educational institution, in the Construction Materials and Construction Techniques laboratory where they were produced. The concrete, both conventional and comparative concrete, and concrete with the addition of activated carbon are produced.

Concrete kneading water meets ABNT normative requirements [15].

3.2.2 The Cement

Portland cement used for the production of concretes in this research was the CEMEX brand CP IV-32; Resistant.

The quality characterization analysis of this cement was performed at the UNINORTE Building Materials and Construction Techniques laboratory - Unit 11, where the following test methods were selected:

a) a) Determination of fineness through 75μm sieve (nº 200) [16];
b) Determination of specific mass [17];
c) Determination of Normal Consistency Paste [18];
d) Determination of catch times [19];
e) Determination of compressive strength [20].

3.2.3 The Aggregates - Kids (sand) and Graves (gravel 0)

The aggregate characterization analyzes were also performed in the laboratory mentioned in the item above. The test methods used and that comply with the procedures of ABNT technical standards were:

a) Determination of particle size composition [21];
b) Determination of unit mass and void volume [22];
c) Determination of specific mass and apparent specific mass [23];
d) Determination of specific mass, apparent specific mass and water absorption [24].

3.3 Chemical Analysis of Activated Coal

3.3.1 Spectrophotometry

Methyl orange (for absorption) and methyl blue (for adsorption) solutions were prepared in the following manner:

- ✓ 25ml distilled water;
- ✓ 2,5g both methyl orange and methylene blue and,
- ✓ 5g activated carbon.

3.3.1.1 Absorption by Methyl Orange

Knowledge of light absorption by matter is the most common way of determining the concentration of compounds present in solution. The great advantage of using colored compounds is that they absorb visible light (visible region of the electromagnetic spectrum) [25].

When we use spectrophotometry as a measurement process, we are basically employing the properties of atoms and molecules to absorb and emit electromagnetic energy in one of the many areas of the electromagnetic spectrum [26].

Since the interaction of light with matter depends on the chemical structure of the compounds, the absorption spectrum is a characterization that allows us to verify the wavelength range in which a given compound has its highest absorption affinity [25].

For this analysis, methyl orange was used for the absorption procedure. Next, Figure 4 shows the methyl orange in the beaker cup on the funnel rim with the activated charcoal inserted.

Figure 4 - Analysis of activated charcoal through methyl orange being prepared for spectrophotometry.
Source: Authors (2019).

3.3.1.2 Adsorption Through Methylene Blue

Methylene blue (MB) is a cationic dye and has a variety of applications, being used in dyeing cotton, wool and paper, temporary hair dyes, etc. Due to its strong adsorption on solid supports, methylene blue often serves as a model compound for the removal of dyes and organic contaminants from aqueous solutions. [27]. For the adsorption of activated charcoal, the methylene blue dye was used, as shown in figure 5 below.

Figure 5 - Activated carbon adsorption analysis through the methylene blue dye filtration.

Source: Authors (2019).

3.4 Concretes

3.4.1 Preparation of Dosage Unit Traits

Tables 1 and 2, below, show the quantity of materials used in the dosing and preparation of specimens of the respective concrete: conventional and the activated carbon addition through the characterizations previously made for a 30MPa concrete.

Table 1: Unit trait and material consumption in m³ and kg for making conventional 30MPa concrete.

Unit Trace (Kg) - Conventional Concrete			
Cement	**Grit**	**Gravel 0**	**Water**
1,00	1,06	2,84	0,50
Material Consumption for Concrete (1m³)			
Cement (Kg)	**Grit (m³)**	**Gravel 0 (m³)**	**Water (L)**
447	0,338	0,785	224
Material Consumption for Concrete (1m³) - Kg			
Cement (Kg)	**Grit (kg)**	**Gravel 0 (kg)**	**Water (L)**
447	385	1.361	224

Source: Authors (2019).

Table 2: Unit trait and material consumption in m³ and kg for 30MPa concrete preparation with the addition of activated carbon.

Unit Trace (Kg) - Activated Carbon Addition Concrete				
Activated charcoal	**Cement**	**Grit**	**Gravel 0**	**Water**
2%	0,98	1,06	2,84	0,50

Material Consumption for Concrete (1m³)			
Cement (Kg)	**Grit (m³)**	**Gravel 0 (m³)**	**Water (L)**
438,1	0,417	0,733	223
Material Consumption for Concrete (1m³) - In Kg			
Cement (Kg)	**Grit (kg)**	**Grave 0 (kg)**	**Water (L)**
438,1	474	1.271	223

Source: Authors (2019).

The composition of unit traits for the dosing and preparation of concretes is based on the method of the Brazilian Portland Cement Association (ABCP) [28].

3.4.2 Molding of Specimens (CP)

This test method meets the procedures established by the ABNT standard [29]. The formwork has the dimensions of 100mm in diameter and 200mm in height. For each made of concrete, 6 specimens were cast from the concrete with the addition of activated carbon and 5 from the conventional concrete, totaling 11 CP's, as shown in Figure 4 below.

Figure 6 - Newly molded specimens. The front ones (5) are conventional and the rear ones (6) are with activated carbon.
Source: Authors (2019).

The slump test to determine concrete consistency between 80mm and 100mm was found 90mm according to ABNT normative prescriptions [30].

3.4.3 The Healing of the Test Bodies (CP)

In the curing process of the concrete specimens, the established ages were 7 and 28 for the 2 dosages performed, leaving 2 CP's, of each made trace, for control or subsequent tests. The water used to supply the tank is supplied by the public water supply of the city of Manaus, ÁGUAS DE MANAUS S / A, acquired at the Building Materials Laboratory of the aforementioned institution, which meets the ABNT normative specifications [15], already mentioned in scope of this research.

3.4.4 The Breakdown of the Test Bodies (CP)

For the test of compression of the specimens, the determinations of the ABNT standard [31] were used as reference. The equipment used for the ruptures was a CONTENCO electric hydraulic press (I3025-B), located in the UNINORTE Unit 11 Building Materials and Construction Techniques laboratory. Below, Figure 7 shows one of the specimens positioned on the press awaiting breakage.

Figure 7 - Specimen positioned awaiting rupture through the digital hydraulic press.
Source: Authors (2019).

3.5 Additional Analysis

3.5.1 Analysis of Filtered Water in Concrete Specimens - Alkalinity, pH and Chlorine

For the procedures of water quality filtered by the permeable concrete specimens of alkalinity, pH and chlorine content, very common methods were used, especially for those who have a pool in their residence. These methods were chosen so that there was a pre - analysis to verify the quality of this water. These methods are found in swimming pool stores where you will find the manual on how to carry out the experiments and the amount of chemical and water needed for this analysis.

4 drops of each reagent arranged in the kit were added. On the chlorine (CL) side the reagent is called orthotolidine shown as solution B and on the pH side the reagent is called phenol red identified as solution A. The filtered water was added to the tubes and then the solutions corresponding to its indicated side, sealed, shaken and rested for 30 seconds. After the elapsed time, readings were performed according to the color and intensity indicative for each analysis.

Figure 8, below, show the methods used as well as the analyzes performed on the specimens detailing the equipment used for water filtration.

Figure 8 - Materials and equipment arranged on the bench for the filtration of water in the concrete's CPs for analysis.

Source: Authors (2019).

4 - RESULTS AND DISCUSSIONS

4.1 Spectrophotometry

Spectrophotometry is the optical analysis method most used in biological and physicochemical investigations. It is based on the quantitative measurement of light absorption by solutions, where the concentration in the solution of the absorbent substance is proportional to the amount of light absorbed.

4.1.1 Absorption by Methyl Orange

The absorption curve is used to measure the ideal wavelength of a technique. When a substance is subjected to several spectrophotometer absorbance readings over a range of electromagnetic wavelengths, its light absorption capacity can be assessed. This absorption is represented graphically by wavelength values and their respective absorbances, forming the absorption curve [32].

For this research, according to the data collected, a methyl orange absorption curve was made using a reading range between 600nm and 700nm of electromagnetic wavelength. Each wavelength was read and its corresponding absorbance values were recorded according to table 3 below.

Table 3: Results found by spectrophotometric absorption analysis using methyl orange.

Absorbance (Abs)	Wave-length (nm)
600	0,82
620	0,10
640	0,91
660	0,48
670	0,21
680	0,10
690	0,36
700	0,62

Source: Authors (2019)

Through the absorbance values found as a function of wavelengths, it was possible to graph the absorption curve of methyl orange (figure 9). From the graph, it is noted that the ideal absorbance value found to measure methyl orange concentration is 640nm.

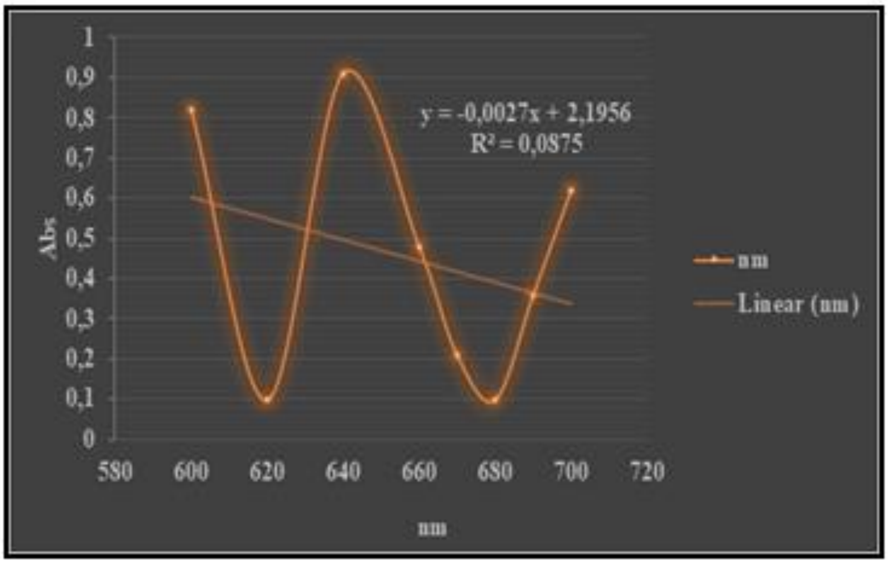

Figure 9 - Graph of the absorbance curve through the activated carbon methyl orange (AC).
Source: Authors (2019).

4.1.2 Adsorption Through Methylene Blue

Methylene blue is adsorbed onto microporous sized scales (0.8-2.0nm) and mesoporous (2.050nm), and the iodine molecule is adsorbed onto micropores (less than 0.8nm) [33].

The activated carbon produced for this research constituted a test for the adsorption capacity through the methylene blue dye. The spectrophotometric analysis aimed to investigate the potential of activated carbon as adsorbent providing subsidies for liquid effluents, in the case of this research, the water filtered by permeable concrete. Adsorbate selects molecular sizes and electronic properties, which makes activated charcoal favorable for the investigation of adsorption in pores of different microscopic dimensions.

Table 4 below shows the adsorbed concentration of activated charcoal by means of the methylene blue dye and, for better adsorption visualization, the graph (figure 10) shows the adsorbed percentage.

Table 4: Analysis of the concentration of methylene blue dye in% adsorption of activated carbon according to temperature.

Activated Carbon / Temperature	Methylene Blue Dye Concentration (mol / L)	(%) Adsorption
200	0,056	95,8
300	0,035	96,6
400	0,049	96,3
500	0,059	95,6
600	0,056	95,8
700	0,105	92,1

Fonte: Autores (2019).

Figure 10 shows the graph of the percentage of activated carbon adsorption according to its temperature through the methylene blue dye, a stable behavior and a percentage decline in the temperature of 700 ° c.

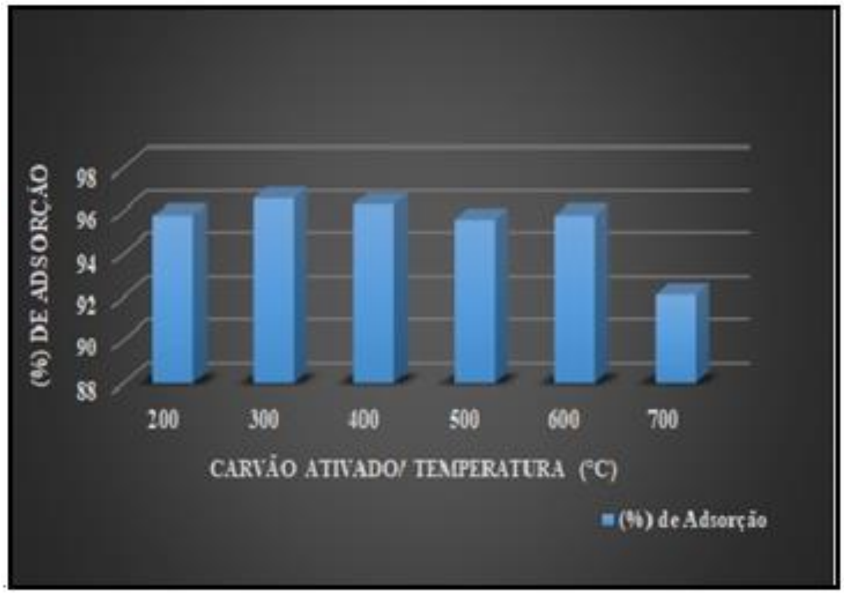

Figure 10 - Graph of% adsorption of activated carbon according to its temperature through methylene blue dye.
Source: Authors (2019).

4.1.3 The Breakdown of the Test Bodies (PC)

Table 5 below shows the results of the mechanical strength of concrete, both conventional and with the addition of activated carbon, through axial pressure rupture with the aid of digital hydraulic pressure.

Table 5: Results of concrete specimen rupture according to their curing ages.

Compression Resistance of Specimens						
Concrete Traces	**Bursting Load (Kgf)**		**Compressive Strength (MPa)**		**Average - 07 days (MPa)**	**Average - 28 days (MPa)**
	07 days	**28 days**	**07 days**	**28 days**		
Convenc.	23490	25930	29,9	33,0	**29,12**	**34,24**
	22250	27840	28,3	35,4		
With Addition of Activated Carbon	18290	23440	23,3	28,8	**23,05**	**32,27**
	17920	28030	22,8	35,7		

Source: Authors (2019)

It is observed that both types of concrete reached the expected estimates and determined by the dosage, and the concrete with the addition of activated carbon had a small reduction in its mechanical strength. If the result were below the calculated estimates, the counterproof would have to be broken to state that the material would decrease the resistance, which was not the case.

Also, according to table 5, a graph (figure 10, below) was made with the results found in MPa, through the arithmetic mean between them according to their referent ages.

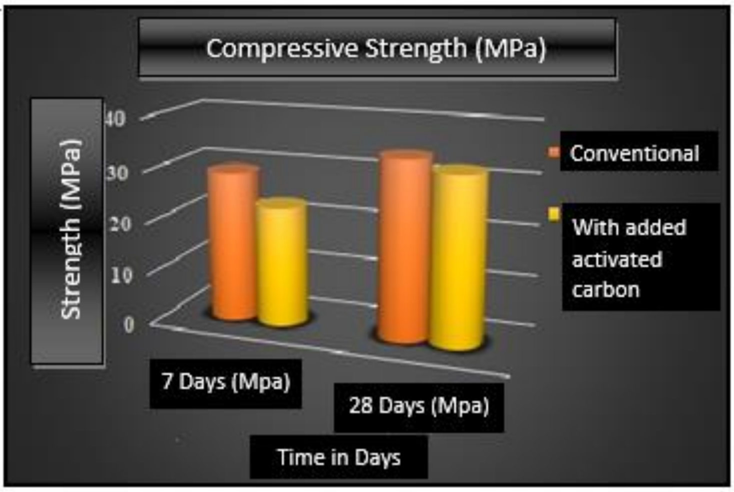

Figure 10 - Graph referring to the results of PC ruptures in MPa according to their respective ages.
Source: Authors (2019)

4.1.4 Analysis of Filtered Water in Concrete Specimens - Alkalinity, pH and Chlorine

PH has the meaning of Hydrogenionic potential, ie the amount of protons (H +) in an aqueous solution, which indicates acidity, neutrality or alkalinity. The ideal value for pH to be recommended for use is 7, which means neutrality, below that means acidity and above that value means alkalinity.

Figure 11 below shows the water filtration analysis on the conventional concrete specimen, with the alkalinity, pH and chlorine measurement completed. It is noted that the results, although the color of the water is cloudy, it is possible to determine the values found, but not so accurately. The pH result is between 7.6 and 7.8, where it can be noted that where it ranks best is 7.6 with the ideal pH depending on the equipment. Thus, it can be said that alkalinity is almost out of the ordinary.

Figure 11 - Water quality procedure filtered by conventional concrete.

Source: Authors (2019).

The amount of chlorine, also could not be identified according to the equipment, and may be below the last value of the equipment, ie 0.5.

Figure 12 below shows the results of water filtration through the activated carbon addition concrete specimen.

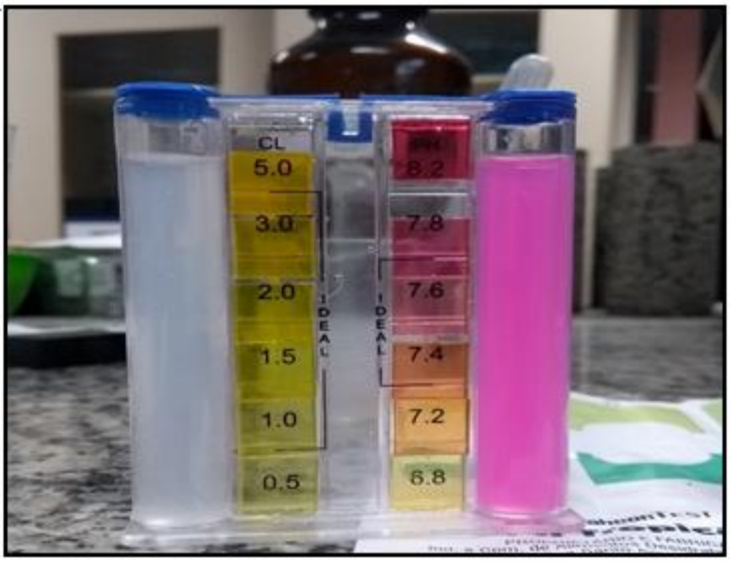

Figure 12 - Concrete filtered water quality procedure with the addition of activated charcoal.

Source: Authors (2019).

It is observed that the pH color of the filtered water with the addition of activated carbon is totally different from the color of the filtered water of the conventional concrete, which is between 7.2 and 6.8, which may indicate an acidity in the filtered water. But, only a more detailed analysis to identify. However, that was the best result.

5. CONCLUSION

Water quality is of utmost importance to us living beings and especially us humans. Unfortunately, few companies, both public and private, care about the final destination of this wastewater. Civil construction is one of the main causes of the neglect of this fluid so important to our health and well-being, with deforestation, with the deviation of its course, among other cases. The lack of basic sanitation and sewage treatment as a form of water reuse, has a huge environmental impact and a lack of education in relation to the population of which the public agencies do not provide society with a better life condition. With this in mind, this research not only enabled a permeable concrete for light traffic pavement but also cared how the quality of this effluent would return to nature.

The various characterization analyzes of materials pertinent to the concrete composition regarding the quality of the activated carbon applied in this research had an excellent success. Thus, it can be affirmed that this new product can be commercialized for civil construction being viable for use, presenting sustainability for the project. All analyzes were essential to the composition of the scope of this research. The absorption and adsorption analysis of activated carbon contributed significantly to the results found by spectrophotometry with 640nm of methyl orange concentration through its absorbance, as well as the content of the adsorption percentage of 95.6%. For the mechanical strength through the rupture of the concrete specimens, they had an arithmetic average of 34.24 MPa at 28 days of cure. 28 days. In the performance of water quality filtered by permeable concrete, the most acceptable material is that with the addition of activated charcoal with values between 6.8 and 7.2. Therefore, the technical feasibility of using permeable charcoal in permeable concrete for light traffic paving is stated.

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