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HEAVY METALS MODELING IN THE WATER FLOW AND SLUDGE OF THE BENTHONIC ECOSYSTEM OF THE BOGOTA RIVER - COLOMBIA

MODELADO DE METALES PESADOS EN EL FLUJO DE AGUA Y LODOS DEL ECOSISTEMA BENTÓNICO DEL RÍO BOGOTÁ – COLOMBIA

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Abstract
Industrial processes have created environmental problems because of the discharge of pollutants into the environment. Especially the water bodies have been contaminated by HM heavy metals. The Bogotá river has registered a considerable increase in these HM as it advances in its channel towards the Magdalena river without its effects on the benthic ecosystem have been established. The present study used the Bogotá river as a study source. This is born in the municipality of Villapinzón-Colombia and empties into the Magdalena River. The selected sampling points correspond to sectors where anthropogenic activities are carried out. The results showed the relation of its concentration for various metals, developing for each one the calibration curves in the water and the sediments. Although high concentrations were obtained in some sectors, they were within the parameters established by Colombian legislation.

Keywords—Heavy metals, benthic sludge's, water stream, pollution

Resumen
Los procesos industriales han creado problemas ambientales como resultado de las descargas de contaminantes al medio ambiente. Especialmente los cuerpos de agua han sido contaminados por metales pesados HM. El río Bogotá ha registrado un aumento considerable en estos HM a medida que avanza en su cauce hacia el río Magdalena sin que se hayan establecido sus efectos sobre el

ecosistema bentónico. El presente estudio utilizó el río Bogotá como fuente de estudio. Este nace en el municipio de Villapinzón-Colombia y desemboca en el río Magdalena. Los puntos de muestreo seleccionados corresponden a sectores donde se realizan actividades antropogénicas. Los resultados mostraron la relación de su concentración para varios metales, desarrollando para cada uno las curvas de calibración en el agua y los sedimentos. Aunque se obtuvieron altas concentraciones en algunos sectores estas estaban dentro de los parámetros establecidos por la legislación colombiana.

Palabras clave
metales pesados, río Bogotá, lodo bentónico.

1. INTRODUCTION

The accelerated development of industrial processes have generated environmental problems as a result of discharges pollutants emitted to the natural environment, especially to the bodies of water, their contamination with HM is considered highly dangerous as these do not have any kind of biological degradation or chemistry, in addition to being bio-accumulated of inorganic form or as organic compound, remaining in the body of the living beings for long periods of time (Förstner, et al. 1974).

In excerpts of some research is makes mention to analysis of HM realized in the waters, in some sectors of the Bogotá River, where we could appreciate a reduction of these as the waters are moving along the river, leaving in the air the idea of not having established the final destination of the HM and that could be passing with regard to their effects on the environment. (Acosta et al., 2002 ; Rivera et al, 2017).

For the present study was used as the basis the Bogotá River, which begins in the municipality of Villapinzón to 3200 amsl (above mean sea level). to 5°13' north latitude and 73°32' west longitude, to lead in the Magdalena river by its right margin and to the east of the city of Girardot, at 4°18' north latitude and 74°48' longitude west of Greenwich.

Has a course of 255 km., on his journey irrigated lands of 26 municipalities, including the western area of the Capital city (Cortes, 2016).

Selected sampling points, taking into account that its location corresponds to sectors where they develop anthropic activities, there are samples of sediment and water for their analysis physical, chemical and study to scale; through the implementation of the samples in columns or reactors; one of characteristics anaerobic completely mixed and another features aerobics, where it took into account the activity of methane genesis of them. The results showed the relationship of patterns and their concentration for each metal, developed for the generation of the calibration curves of the waters and sediments.

Most metals are within the limits set by the standard of the Decree 1594 of 1984. Although in some sectors were concentration readings high, they are well within the parameters established by the Decree, however most of the data are for the water column, but most of the concentrations found in sediments.

2. THEORETICAL FRAMEWORK

The present pollutants in the environment represent a potential threat for the existence of the human beings; these include a wide range of substances of very diverse chemical structure, are usually classified into two large groups:

- Trace elements and organic metal
- Organic Substances

These two groups, have features that you are common to all them, although they may differ widely in their chemical structure, although they possess certain physical properties similar; some are resist degradation processes and are very stable in the media, others have the quality of accumulate in foods and consequent to be consumed endanger human health due to its slow rate of removal. Although some trace contaminants metallic are indispensable in the organism its deficiency can cause health problems, and if it exceeds the range of security can be highly toxic (Falco et al. 2012).

Environmental pollution is caused by toxic agents from different sources among which:

- The natural presence.
- The industrial pollution.
- The industrial processing
- The agricultural technologies

A. The natural presence

The condition of geological many elements in the terrestrial crust makes the HM are in a natural way, dissolved in all aquatic systems and in different degrees of concentration through the orogenic processes; aquatic ecosystems are subjected to contributions of metallic compounds from soils, part volcanic activity and erosion are factors contributing to the increase of the concentrations of metals in the middle, being the sources of transport more common sources of water and the winds. (Manahan, 2007; Rodríguez, 2017).

B. The industrial pollution

Industrial processes are the main source of pollution and deterioration of the aquatic environment, given its great variety and the use of different materials raw e inputs necessary for the development and production of new technologies. The quantities in metric tons, issued annually throughout the world for some metals are led, 2'000.000; Cadmium, 5500; mercury, 11000 and arsenic 78000, Falco (2012), these figures are 300 times higher than natural emissions. The industries galvanic or finishing of metals, produce a series of debris that usually contain acids, trace metals, cyanide, and chrome. These come from the processes of burnishing the steel, iron, and copper, and the processes of electro plating (Sierra, 1985; Giraldo, 1995).

The wastewater from the burnishing the steel has a large content of acids and ferrous iron; these wastes are very difficult to treat and very toxic to the microorganisms (Urrutia et al. 2002).The burnishing the copper, washing and processing will be translated in the presence of the mineral in the liquid waste, even at low concentrations this metal is toxic to aquatic life and disturbs the biological processes of wastewater treatment. The waste product of the processes of the electroplating are extremely toxic since they generally contain cyanide and cyanates (Stephens et al. 2009).

C. The industrial processing

Some manufacturing processes can contribute to the increase of trace elements in the natural environment, through wastewater discharges, without any type of treatment, to the natural currents, causing its gradual deterioration. See Table 1.

TABLE I. INDUSTRIAL PROCESSES IN WHICH HEAVY METALS ARE USED

INDUSTRIAL PROCESS	Cd	Cr	Cu	Fe	Hg	Mn	Pb	Ni	Sn	Zn
Paper and cardboard production		X	X		X		X	X		X
Petrochemical and Ind. Organic Compounds	X	X		X	X		X		X	X
Chemistry Ind (caustic soda and other)	X	X		X	X		X		X	
Fertilizers production	X	X	X	X	X	X	X	X		X
Refinery	X	X	X	X			X	X		X
Metallurgical Ind.	X	X	X	X	X		X	X	X	X
Production of different metals to iron		X	X		X		X			X
Cars and airplanes Industries	X	X	X		X			X		
Glass, cement, and asbestos industry		X								
Textile industry		X								
Leather Industry		X								
Steam plant (boilers)		X								

D. The agricultural technologies

The presence of HM in the ecosystem by causes of agricultural technologies, is due to the use of different types of agrochemicals that contain this type of elements (Sierra, 1985).

Toxic effects of heavy metals in the human body

The toxicity of heavy metals is based on the influence they have on the physiological processes of the organisms, Cruz-Guzmán, (2007), being the greatest danger the Lead (Pb), Cadmium (Cd), and mercury (Hg).

Mercury is one of the heavy metals more used and is considered a poison for the natural environment, its toxicity develops in the form of organic and inorganic compounds. The mercury salts to be downloaded to the aquatic environments are transformed by the action of bacterial activity, under certain environmental conditions (in waters with low nutrient content and high content of oxygen the methylation process is more accelerated), in organic compounds methylmercury is a compound highly toxic and soluble in fat. (Cruz-Guzmán, 2007).

The cadmium is a secondary product of the removal of the Zinc, near the 0.2% of the Zinc Metal is the cadmium; its toxicity is very complex and is based on the multiple possibilities that has to form macromolecules, as for example replacing other metals that play an important role in the enzymatic activity and reacting with groups of biological assets (carboxyl, phenol, sulphides and others). The cadmium together to lead and mercury react especially with the sulphides groups (SH-).

The lead is another metal very toxic, like mercury toxicity has two routes; as a compound inorganic is called search engine of bones, since it is there where it accumulates and it has been verified that the 90% of lead in the body accumulates in these; the other way is the organic compound, more widely known as they are used as additives anti-knock in the gasoline.

3. METHODOLOGY

Samples were taken using the system instantaneous, which reflect only the conditions at the time of sampling, these were taken from the sediments to the bottom of the river in the central part of the riverbed, taking two points by sector, at a distance of 50 m. between one and another, and at an average depth of 0.40 m., through a system of borehole background, designed for this project. Once obtained samples of the two points of the sector is applicable to homogenize, for mounting the columns. The samples were stored in glass jars sterilized prior, without any type of preservation, in cool dark place for reassembly in columns;

samples for sulphides were preserved by setting the same by adding reagents.

Characteristics of the Columns

Physically the columns were assembled with a PVC pipe of φ 4' and approximately 40 cm long, with a cover and a base in acrylic hermetically closed, using a flange secured with screws, with three entrances for connections or removal of samples that are located on the side of the cylinder to 10 cm, 25 cm and 40 cm measured from the cover.

A. Aerobics column

This column presents a constant supply of air through a pump connected to an access valve located in the lid, the air is induced when liquid medium through a diffuser, avoiding any kind of disturbance in the sediments. This column is transparent allowing the passage of light, facilitating the activity of some algae, see figure 1.

Fig 1. Aerobics column.

B. Anaerobic column

This column type presents at the top, unlike the aerobic, a system of slow rotation, by means of a motor, which activates the rotation of a Helix, producing a continuous movement slow fluid, which emulates the one produced by the current of the river and trying to avoid the most sediment present some kind of disturbance, *s*ee *f*igure 2.

Fig 2. Rotation system slow

4. RESULTS

The following data are the results of the analysis of the traces of heavy metals, once read in the atomic absorption spectrophotometer and their respective correction, respect to whites, as to the calibration curve.

The following tables show the relationship of patterns and their concentration for each metal, developed for the generation of the calibration curves of both the waters as for sediments.

For the development of the calibration curve for each metal, was submitted to the whole process of extraction and reading to each one of the dilutions for getting the following results (Bowels, 1981).

With regard to the minimum concentrations detectable - MDC for water to each metal is resorted to the calibration curve which is shown in figure 3, and in the place of court are obtained the concentration values minimal detectable for each metal, however when these values are very small is required to expand the sector of the curve where there are inconsistencies, crossing the curves of the patterns metallic with the value of the noise of the spectrophotometer is established the values of minimum concentrations detectable cmd, that for each metal are:

- Chromo 0.003 ppm. - 3 ppb
- Cadmium 0.002 ppm. - 2 ppb
- Lead 0.004 ppm. - 4 ppb
- Nickel 0.012 ppm. - 12 ppb

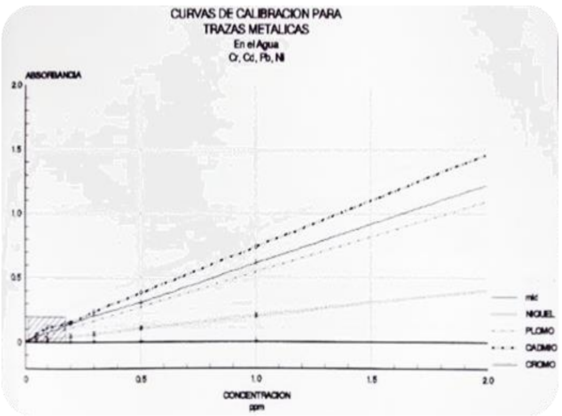

Fig 3. Calibration curve for trace metals in water

In regard to the MDC for the sediment, for each metal in the sediments are repeated the process, recourse was had to the calibration curve which is shown in figure 4, in the same manner as was done with the water, resulting in the following values of minimum concentrations detectable (mdc):

- Chromo 0.048 ppm. - 48 ppb
- Cadmium 0.011 ppm. - 11 ppb
- Lead 0.130 ppm. - 130 ppb
- Nickel 0.150 ppm. - 150 ppb

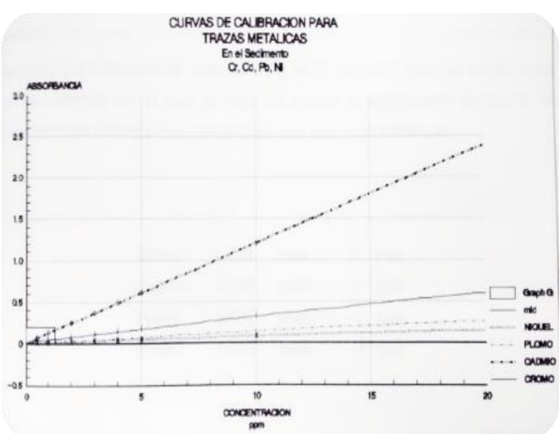

Fig 4. Calibration curve for trace metals in the sludge Benthic.

5. CONCLUSIONS

According to the results obtained in the laboratory, metals analyzed in this study, the Lead (Pb) and nickel (Ni) are presented in a greater concentration in the water column above the CR and the Pb; concentrations of 251 ppb for lead and 187 ppb for nickel (Ni) in the column of water, can be highly detrimental to living organisms.

The high concentrations obtained in the column aerobics in comparison with those of the anaerobic, can be caused by the system of aeration, that by reducing the volume of water in this column, by the extractions, able to come into contact with the sediment producing a disturbance of the same by releasing the metals concentrated in this. Another reason may be the disappearance of the protective layers of phosphate.

The transfer of heavy metals between the sediment and the water column does not seem to be presented in a manner diffuse, but the volume of water of the column, returned by water of dilution, is an obvious resuspension and an increase in the concentrations due to the tendency of metals to be set of suspended solids.

There was the trend that have cadmium and lead to remain in the sediment, not presenting transfer naturally with the water column.

Most metals are within the limits set by the standard of the Decree 1594 of 1984. Although in some sectors were concentration readings high, they are well within the parameters established by the Decree, however most of the data are for the water column, but most of the concentrations found in sediments.

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