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Water Quality of the Poza Honda Dam and Other Water Points Down

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Abstract

The phenomenon of pollution of water basins is eliminating many potential water resources. Most of the pollution in Ecuador comes from household waste and agricultural chemicals, especially along the coast. One of the activities in the management of the water resource is the periodic monitoring of the bodies of water, being able to determine the different changes that occur and to influence through preventive actions that manage to reduce the pollution. The water resource is the articulating axis of all the activities in a territory and therefore of the populations that develop different productive activities that not only depend on the quantity and quality of this resource but also generate alterations to the natural state of the same. In the investigation, the monitoring of the quality of the water in different points of the Poza Honda dam and of the river Portoviejo is carried out. The study aims to manage the pollution processes that occur in the aquifer, due to the depositions of domestic, industrial and agricultural wastewater not controlled to be discharged. It was verified that as the distance of the Poza Honda dam increases and the passage of the river through different settlements, appear characteristic of the water that is not in agreement with the regulations of quality of the precious liquid, due to the controlled unloading of different Types of residuals to the aquifer.

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1. Introduction

Since the earliest times, water has been a key factor in the development and political, social and economic structuring of peoples. It is considered that water is one of the fundamental elements of life, thanks to it man can develop and transform nature in his favor (Pedro, 2010).

Humans have stored and distributed water for centuries. At the time when a man was a hunter and gatherer, the water used to drink was river water or natural deposits. When human settlements took place continuously, they always took place near lakes and rivers. When there were no lakes and rivers, people took advantage of the groundwater resources that could be extracted through the construction of wells. When the human population began to grow extensively and there were not enough available water resources, it was necessary to look for alternative sources (Rotterdamseweg, 2016).

The amount of water that exists on Earth does not increase or decrease, but the human population has grown exponentially in recent years and therefore the need for this resource has increased (Mazari *et al.*, 2005). In some regions of the world, it is a limiting factor for human health, food production from agricultural activity, industrial development, maintenance of natural ecosystems and their biodiversity and even for social and political stability (Carabias and Landa, 2005). The health of an aquatic ecosystem is essential and depends not only on the quantity of water but mainly on its quality (Díaz, 2005).

Roman architects stood out for the construction of water distribution networks, hydraulic works that have existed throughout history. They used groundwater resources, rivers and runoff water for their provisioning. They built dams for the artificial storage and retention of the precious liquid.

The aeration treatment system was used as a purification method. The water of better quality and therefore more popular was the water coming from the mountains. The aqueducts were used to transport the water. Through these flowed for thousands of miles. Pipeline systems in the cities used Roman cement, rock, and bronze, silver, wood, and lead. Water sources were protected from external contaminants (Díaz, 2005).

The relationship between water quality and health has always been known. The clear waters were considered clean waters, while the swamps were considered dirty areas. Disinfection of the water has been used for a long time. Two basic rules can be found in 2000 BC, which said that the waters had to be exposed to sunlight and filtered with charcoal. The impure water was boiled and a piece of copper was introduced seven times before the water was filtered. There are descriptions of ancient civilizations in reference to boiled water and their storage in silver containers. To carry out the purification copper, silver and electrolysis techniques were used (Díaz, 2005).

In centuries past man has suffered diseases like cholera and others whose origin was misinterpreted. These diseases were said to be caused by God's punishments or due to the impurity of the air, which was a consequence of the change in alignment of the planets.

In 1854 the cholera epidemic caused a great number of deaths in London. John Snow, an English doctor discovered that the cholera epidemic was caused by the pumping of contaminated water. The expansion of cholera was avoided by the closure of all pumping systems, after which the scientists have conducted studies and investigation of the presence of microorganisms in the water and the mode of disposal for their supply fit for consumption (Díaz, 2005).

Currently, man uses large amounts of water for his daily activities, but much more to produce food, paper, clothing, and other products that he consumes. The water footprint of a country is defined as the total volume of water used to produce the goods and services consumed by its inhabitants. The concept of water footprint was introduced in order to provide information on the use of water by different sectors. The main factors that determine the water footprint of a country can be the average water consumption per capita, related to gross national income; The consumption habits of its inhabitants; The climate in particular evaporative demand and; Agricultural practices (Pedro, 2010).

Particularly in Ecuador of every 100 liters of water, 81.1 are consumed in agriculture, mainly for irrigation activities; 12.3 in domestic use; 6.3 in the industry and; 0.3 in other uses (Senagua, 2011). Surface water pollution occurs primarily from domestic, agricultural, and industrial sources, occurring around the country, especially near highly populated areas. Nearly all rivers near urban areas have high levels of biochemical oxygen demand (BOD), nitrogen and phosphorus. Also, brackish water to saline is found in some coastal zones and in river deltas (Pedro, 2010).

The Poza Honda Dam located in the province of Manabí is a hydraulic reservoir built between 1969 and 1971 in the upper part of the river Portoviejo. It is located 30 kilometers from the provincial capital city and represents an area of high agricultural productivity for the territory. Its water is stored by means of dams of diverse dimensions that are used for agricultural irrigation, livestock, recreational activities, as well as domestic use.

The Portoviejo river along its channel is a receiver of sewage from various populations, which incorporate organic matter, pesticides, polycyclic aromatic hydrocarbons (PAHs) and other contaminant residues into the river.

The objective of the study is to study the water quality index (SWQ) in the Poza Honda dam and some points of the river Portoviejo, based on the problem that exists when the river overflows, dragging solids in suspension, which not only Affect crops in agricultural areas and private property by the disposal of chemical residues used in agriculture, which are highly toxic and none of the potable water treatment plants have the respective process units that can eliminate these substances harmful to health.

The physical, chemical and biological characteristics of water determine its quality; these characteristics can be modified by natural processes. During the natural cycle of water, it may have contact with substances or microorganisms that are discharged in it, being possible to mention dissolved and suspended organic substances and organic, such as arsenic, cadmium, bacteria, clays, organic matter, besides man-made contaminants And which are dumped directly or indirectly into the watercourse. The work evaluates the physical, chemical and biological characteristics of the water using the environmental quality standards and discharge of effluents applied to this natural resource, contained in the Unified Text of Secondary Legislation of the Ministry of the Environment of Ecuador (Mae, 2012).

2. Materials and Methods

The research has been based on experimental descriptive and field type, studies of photographic documentation and available bibliography; In addition to the compilation of technical elements and criteria obtained from the Manabí technical authorities, which, with their guidance and knowledge, provided the fundamental guidelines for establishing the study. The dependent and independent variables were observed and the techniques required to develop the research were generated.

Three points were selected to extract samples and the initial values of the parameters established for the study were quantified, in each site the frequency of monitoring and the parameters to be measured were determined based on anomalies found in the information collected along the Portoviejo river, using the road that starts at the Poza Honda Dam and three others at nearby points located in Honorato Vásquez, Ayacucho, Santa Ana, Portoviejo and Picoazá. Sampling was performed during the 2 seasons (3 in the winter and 3 in the summer), which allowed the analysis of the water quality of the Portoviejo River and the Poza Honda dam.

3. Results and Discussions

The Portoviejo River is the main source of water for more than seven hundred thousand inhabitants residing in the capital city of the province and the cities of Manta, Jipijapa, Rocafuerte, Montecristi, Santa Ana, Jaramijó, May 24 and part of Sucre. Some 300,000 people live on its shores, where there is an intense agricultural activity that has life in its valley, although its value added is very low. In rainy winters causes floods in the city and in the countryside (Julio, 1987).

As an environmental object of provincial importance and all the benefits provided by the Portoviejo River, it is currently very neglected. Unconscious people put any kind of rubbish in their beds. Few know its rich history and the great majority does not even care to understand it (Julio, 1987).

Within the channel of the Rio Portoviejo can be observed large quantities of containers and materials of difficult degradation; As well as contributions of wastewater of both human and animal origin. This condition affects the natural dynamics of the river, causing the disappearance and/or extinction of animal and plant species, with a notable reduction in the quantity and quality of the water that it contributes to the province of Manabí.

The entire route of the Portoviejo River has a length of 113 km, along which have been settled important human conglomerates, whose wastewater discharges are finally driven to the river, in most cases has been able to observe the condition Precarious systems of treatment and disposal of sewage, which are undoubtedly generating permanent pollution.

On the other hand it has also been possible to observe the existence of extensive areas of the valley of the River Portoviejo dedicated to agriculture, which are covered by the irrigation system of Poza Honda, which has its origin in the Salazar Barragán Dam from where the two Main channels that have a tracing by the margins right and left respectively.

The research was developed at the Poza Honda dam, located in the coastal region 3 kilometers west of Honorato Vásquez and 30 kilometers southwest of the city of Portoviejo, as well as three points on the river Portoviejo. Figure 1 shows the area selected for research, which coincides with that of the Portoviejo River, which is the main water source for irrigation and human use, with 15 settlements located in an area of about 1 km, Which constitute potential for the dumping of polluting waste into the aquifer; Meaning that the river crosses the city of Portoviejo which is the greatest potential for dumping of wastewater and solid waste.

Figure 1. Rio Portoviejo and the settlements that are to 1 k

It can also be noticed that the Poza Honda dam is located at the source of the river, being the fundamental water supplier that is served in the city and towns of Portoviejo.

The water resource is the axis that articulates all the activities in a territory and therefore of the populations, these develop different productive activities that not only depend on the quantity and quality of this resource but also generate alterations to the natural state of the same.

The Poza Honda dam is a hydraulic work built in the upper part of the river Portoviejo. The dam of more than 12 km in length, contains a reservoir of more than 100 million m^3 of water; Is used for the irrigation of an area of 10 thousand hectares and for the provision of drinking water to the cities of Santa Ana, Portoviejo and Roca Fuerte.

Aggressions to the river start from Santa Ana, where farmers wash coffee and other products on the banks. Then in Portoviejo the discharge of sewage from the oxidation lagoons in Picoazá takes place. Add to that the fact that dozens of families have connected their sewage pipes to storm drains, this situation is observed in the sectors of the hospital Verdi Cevallos and San José bridge, which contaminates much more because the waste is not treated (Margarita, 2003).

In the year 2012 another research affirms that there are reliable quantitative results of laboratory analysis, that allow concluding that from many years ago there is chemical contamination in chloride ions, nitrites and ammonia nitrogen, organic matter, *sulfhydric* gas, carbon dioxide, and carbonates, total solids, And what is more serious, highly positive results in the river sediments of organochlorine pesticides and organophosphates. And it is posted that, although these results are from years ago, the problems persist and have probably been aggravated (Diario, 2012).

The results show the contamination of the waters that receive also some of the agents of pollution such as organic waste, which contain the collective waste of daily life, that its volume is constantly increasing with a population that

Grows and eliminates in some areas excreta and wastes to the river itself, as well as chemical products used in agriculture as insecticides, fungicides, and fertilizers that are brought to the river through surface runoff caused by heavy rainfall in rainy seasons. Figure 2 shows the origin of alterations in water quality.

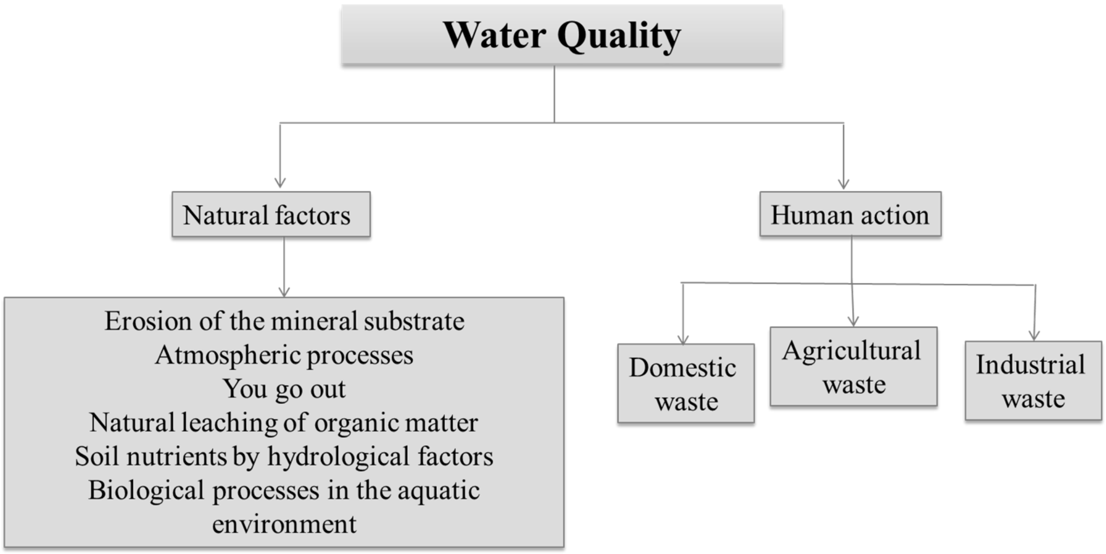

Figure 2. Factors that intervene in water quality in the study area

All this has provoked observations on bio-threatened species in danger of extinction. As they are: the guabina, the old fish, the chillo (catfish), some shrimp (crustaceans) like the creator and the patacho and; Plant species such as the poplar, the fig tree, the gramalote and the guadua cane that previously covered the banks of the river and protected them (Diario, 2012).

The above shows that the current situation of the waters of the river Portoviejo, could present a delicate situation regarding the levels of pollution, being a matter that puts inattention to the authorities of the city and the province, that worried by the high Index of pollution that crosses the water basin of the river Portoviejo, look for joint solutions with several public institutions involved in the subject.

Populations were applied to the populations located near the monitoring points, to structure an idea about the pollution caused by human action, obtaining the graph of Figure 3. The result of the survey shows that more than 90% of the population uses the water of the Poza Honda dam for drinking, cooking and personal hygiene, which represents the primary needs regarding the use of the precious liquid. 67% use water to clean the house and 16% to water the plants.

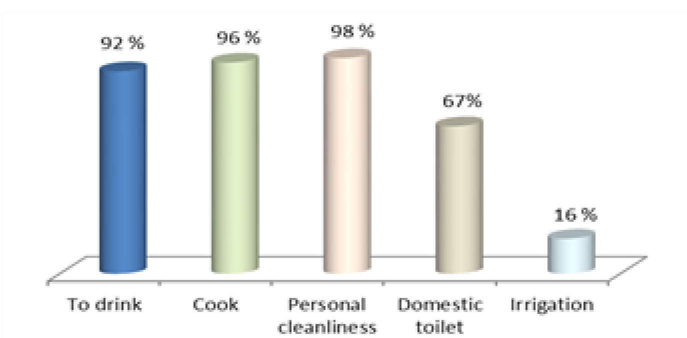

Figure 3. Results on the use of the water of the river Portoviejo and Poza Honda dam

3.1 Results of ICA analysis

The performer of analyzes at the three points sampled at the Poza Honda dam, it was possible to compare the results obtained with the ICA standards in Ecuador. Table 1 shows the altered parameters, which correspond to suspended solids, electrical conductivity, and alkalinity, which in all three cases exceed the index recognized in the Ecuadorian norm. To obtain these results, the methodology developed in the regulations was taken into account. The other parameters are normal according to the standard

An element to be studied is the total coliforms, which are close to the limit established in the regulations.

Table 1
Results of the chemical analysis of the water at the Poza Honda dam

Settings	POZA HONDA						Normative ICA in Ecuador
	POINT 1		POINT 2		POINT 3		
	Superficial (27°C)	Deep + 2m (26,9°C)	Superficial (28°C)	Deep + 2m (27,7°C)	Superficial (28°C)	Deep + 2m (27,4°C)	
Suspended solids (mg/L)	101	109,9	101	103,5	100	101	4 a 20
Electric conductivity (Micro siemens/cm)	212,1	214,1	215	220	207	216	150-200
Alkalinity (mg/L)	116	108	112	106	110	107	<75 75-100 >150

The parameters that differed from the standards were selected, being able to reflect in table 2 the chemical analysis in three points to 300 meters downstream of the Poza Honda dam. In relation to the parameters and requirements required by Ecuadorian regulations, it can be seen that total coliforms are close to the limits established in the regulations, suspended and dissolved solids that are above the range recognized in the standard; the color is above the allowed parameters.

Table 2
Three-point results 300 meters downstream

Parámetros	300 METROS AGUAS ABAJO						Normativa ICA en Ecuador
	POINT 1		POINT 2		POINT 3		
	Superficial (26°C)	Profunda + m (25,8°C)	Superficial (26°C)	Profunda + 2m (25,9°C)	Superficial (26°C)	Profunda + 2m (25,8°C)	
Total Coliforms (nmp/100mL)	>2421,5	>2423,1	>2419,6	>22522	>2422,1	>2510,3	**3000**
Suspended solids (mg/L)	**76,3**	**79,6**	**68,3**	**71,5**	**70**	**73,1**	**4 a 20**
Color (PT-CO)	115	107	120	112	112	115	**100**

In the Boca area at the three points sampled, it was verified that the hardness is above the levels referred to in the standard and that it is classified as "hard water"; Suspended solids are above required; The electrical conductivity behaves between 805 - 843 micro Siemens/cm. Fats and oils, as well as nitrates, are altered. The color and turbidity values are between 403-421 PT-CO, well above the norms, as well as the SAAM (Detergent) is very high, these values are shown in table 3.

Table 3.
Results of the chemical analysis of water in La Boca

Parámetros	LA BOCA POINT 1 Superficial (25°C)	POINT 1 Profunda + 2m (24,8°C)	POINT 2 Superficial (25°C)	POINT 2 Profunda + 2m (24,6°C)	POINT 3 Superficial (25°C)	POINT 3 Profunda +2m (24,7°C)	Normativa ICA Ecuatoriana
Hardness (mg/L)	261	255	269	261	270,1	269,2	100-150
Suspended solids (mg/L)	405	409	408	415	412	419	4 a 20
Fats and oils (mL/L)	<0,41	<0,40	<0,43	<0,41	<0,44	<0,42	0,3
Color (PT-CO)	421	405	415	409	416	403,1	100
Turbidity (NTU)	743	707	732	711	738	714	25
SAAM (Detergent) (mg/L)	2,4	2,1	3,2	2,87	3,54	2,31	0,50

3.2 Evaluation of ICA according to the general criterion

Considering the studies of the ICA analysis from the results of the chemical analysis, the evaluation was performed on the classification of the ICA according to the general criterion, for which equation 1 was applied. Table 4 shows the results of the classification Of the ICA according to the general criterion.

$$ICA = \frac{\sum_{i=1}^{n} I_i W_i}{\sum_{i=1}^{n} W_i} \quad (1)$$

Where:
I → identifies each of the 18 parameters (i = 1,2 ... .18)
n → (18)
Wi → weighting factor according to their respective order of importance (5, 4, 3, 2, 1, 0.5)

Table 4
ICA classification according to the general criterion

Sampling site	Point 1		Point 2		Point 3		Total Average
	Superficial	Depth +2m	Superficial	Depth +2m	Superficial	Depth +2m	
Poza Honda	96	97	97	97	97	96	96
300 meters downstream	97	97	97	97	97	96	97
La Boca	80	80	80	80	80	80	80

According to the rating range of the ICA and considering the general criterion can be evaluated that in the Poza Honda reservoir and 300 meters downstream, the water quality is "uncontaminated" and in the mouth can be evaluated as "acceptable".

The results of the work made it possible to identify that, as the river channel moves away from the Poza Honda dam, the quality of the water decreases and this phenomenon may be related to its passage through the city of Portoviejo, where it can be Producing discharges of contaminating effluents, so it is necessary to periodically maintain the monitoring of water quality in the sampled sites.

4. Conclusion

By conducting the research, it was possible to evaluate the ICA in three points of the Poza Honda dam, another three points 300 meters downstream and three points in the La Boca site, being able to quantify and evaluate the parameters established according to the Ecuadorian regulations. When assessing the results obtained, it was possible to demonstrate that, as the water of the river approaches the mouth, the levels of contamination increase. This situation provides the idea of the necessity to carry out programs of prevention of residual spills to the aquifer.

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Statement of authorship
The author(s) have a responsibility for the conception and design of the study. The author(s) have approved the final article.

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References

Carabias, J., & Landa, R. (2005). *Agua, medio ambiente y sociedad: hacia la gestión integral de los recursos hídricos en México* (No. HD 1696. M6. C37 2005).

Díaz, V. L. M. (1986). *La crisis en la educación y el problema de la criminalidad en Puerto Rico* (Doctoral dissertation, Universidad de Puerto Rico).

El Comercio, D. (2015). Diario El Comercio. *Empresa Editora El Comercio*.

Julio, E. (1987). *Apuntes para la historia de Manabí. Guayaquil*. FB-MCCM-COD 00817. MCMN13074030: Guayaquil Cromos SA.

Lenntech, B. V. (2011). Rotterdamseweg. *The Netherlands, Sources of Heavy Metals (1998-2011)*.

MAE, E. (2005). Texto Unificado de Legislación Ambiental Secundaria.

Mazari Hiriart, M., Cisneros, J., & Vidal, L. (2005). *El agua y su impacto en la salud pública* (No. F/351.82325 P7/4).

Pérez Sánchez, M. (2005). *Análisis de políticas públicas* (No. Sirsi) i9788433837622).

Rodríguez, P. S. (1978). *Testimonio y recuerdos* (Vol. 41). GeoPlaneta, Editorial, SA.

SENAGUA, U. (2009). Secretaria General de la Comunidad Andina. *Informe: Delimitación y codificación de unidades Hidrográficas del Ecuador*.

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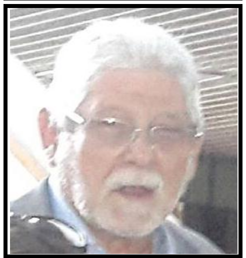	Graduated in Chemical Engineering at the University of Havana and Specialist in Environmental Sanitation at the National Scientific Research of Cuba. He obtained the title of Doctor in Technical Sciences at the Institute of Chemical Technology in Prague. He has Courses on the subject of wastewater treatment in Cuban universities and Latin American universities. Member of the Committee Doctoral of the Technological Institute of Toluca, Mexico, and member of the Court of Scientific Degrees for Chemical Engineering of Cuba. Member of several scientific societies. He is the author of technical articles.
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