# Alteration of Water Sources by Sewage Discharges. Case Study San Andrés, Santander, Colombia

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**Abstract**

The research presents the evaluation of the environmental impacts generated by the sewage discharge into the Guaca River in the area of a neighborhood named La Primavera which belongs to the municipality of San Andrés Colombia, through the Conesa method. In order to carry out the research, information was collected from government entities, and field visits, with the aim of developing an environmental baseline, that would allow an abroad acknowledgement of the municipality's current conditions and the water source, analyzing the biotic, abiotic and social factors. Subsequently, the characterization of the dumping and the Guaca River was carried out in the cemetery's area, La Primavera neighborhood, with the purpose of identifying the physical, chemical and microbiological characteristics that could be affecting the body of water in the municipality of San Andrés. Finally, an examination about the produced impacts was leaded, for creating strategies of environmental control, that sought to prevent and arrange the disturbances generated about the environmental components.

Keywords: Sewage, Water Sources, Environmental Impact, Discharges.

## 1. Introduction

The human activity is purely related to the environment, since human beings make use of nature for obtaining goods and services with the aim of satisfying their basic needs. Some of the activities developed by human beings, generate alterations to the biotic and abiotic components of the environment. These alterations affect the future availability of natural resources [1].

In recent years, due to economic and industrial development, a great amount of wastes have been generated, which do not have an adequate provision, ending thrown into ecosystems, mainly the aquatic ones, because of their constant movement, wastes end up move from one side to another, getting gathered into the bodies of water, causing deterioration on the ground and surface waters [2].

The belonging residues from a sewerage system are liquid substances composed mainly of organic and inorganic contaminants, that can be presented as dissolved or suspended solids, depending on its nature. Sewage is the result of most of the activities carried out by man, principally the productive and agricultural ones. The aforementioned activities produce dumping which represents a series of harmful alterations to the ecosystems; most of these alterations can be irreversible, for this reason, a physicochemical and microbiological treatment of the water is needed before its discharge on the bodies of water, for reducing the impact on the water resource [3].

Sewage is the imprint of a region or area; due to the development of all the economic activities that belong to the productive and agricultural field, generating mainly liquid residues, that cause innumerable damages to the natural resources at not being propperly treated. In order to prevent irreversible damage to the aforementioned resources, it is essential to identify and apply an evaluation of its impacts, with the purpose of discovering the positive and negative alterations that may be generated immediately or over time [4].

The impact evaluation is a tool that facilitates the assessment of the consequences that an activity, installation or project causes to the environment. It is an analysis that envolves different study variables, which anticipate future positive and negative environmental effects, it also allows the creation of management alternatives in order to reduce and prevent impacts [5].

## 2. Materials and Methods

In order to carry out the study, the combination of field work and documentary research was considered [9]; Initially, the information contained in books, technical reports from government entities and scientific articles was collected for building an environmental baseline for the region. Afterwards, the field work was carried out, which consisted of: the characterization of the discharge and the Guaca River in a specific area, surveys to the community and the registration of the flora and fauna characteristic of the area.

Sampling was carried out at 3 strategic points; the first one, 100 meters away the discharge, the second one, in the residual discharge and finally the third one, 100 meters downstream of the discharge. At the upstream and downstream points, punctual sampling and flow measurement was done using the float method; At the discharge point of the sewage, the volumetric method was used in order to measure the flow and the composed samples. Likewise, records of pH and temperature were taken in each sampling; the first parameter was evaluated with the quick litmus paper sample and the temperature with a conventional thermometer.

### Sampling Materials

To execute the monitoring, it was necessary to use elements of personal protection. For the punctual samples the following instruments were used: 2 sterile bottles, 2 wide-mouth 1L glass bottles.

For the composed samples, 12 plastic bottles, 2 plastic bottles of 2L and 2 amber bottles of 250mL were used. For the preservation of the sample, a cellar with ice, sulfuric acid ($H2SO_4$) and hydrochloric acid (HCl) was used.

Once the collected samples were taken, they got brought to the laboratory for analyzing the parameters of: Biochemical Oxygen Demand ($BOD_5$), Chemical Oxygen Demand (COD), Total Coliforms, Total Suspended Solids, Settleable Solids, Fats and Oils for the dumping; Upstream and downstream samples were analyzed for $BOD_5$ and COD. Table 1 presents the methods used in the laboratory.

The impact evaluation was carried out using the Conesa evaluation method, where a-priori the impacts were identified through the matrix method, which establishes a relationship between economic activities and the components of the environment that present changes to the aforementioned activity. Once the generated impacts were established, the environmental impact assessment was carried out by applying the CONESA method.

**Table1.** Analysis methods used in the laboratory (Own authorship)

| **Parameter** | **Method** |
|---|---|
| $BOD_5$ | Incubation 5 days and membrane electrode |
| COD | Closed Reflux- Colorimetry |
| Fats and oils | Liquid Extraction- Liquid, Partitioning Gravimetry |
| Sedimentable Solids | Gravimetry |
| Total Suspended Solids | Gravimetry |
| Total Coliforms | Multicell Enzyme Substrate |

Finally, for finding the importance of the environmental impact, the following algorithm is applied:

I=(3IN+2EX+MO+PE+RV+SI+AC+EF+PR+MC)

Once the importance is obtained, the impact classification is made according to the criteria presented in Table 2.

**Table 2**. Hierarchy of the Conesa methodology Arboleda, 2008

| | | |
|---|---|---|
| Under 25 | Irrelevant | |
| Between 25 & 50 | Moderate | |
| Between 50 & 57 | Severe | |
| Above 75 | Critics | |
| When they are positive, they are considered null. | | |

## 3. Results and Discussion

San Andrés is located at the northeast of the department of Santander, it belongs to the province of García Rovira; Its coordinates are: 6°48'30” North latitude and 72°50'53” West longitude. It is located at 1,675 meters above sea level and has an area of 278 km2. It limits to the north with the municipality of Guaca, to the east with the municipalities of Cerrito, Concepción and Málaga and to the south with the municipality of Molagavita. [6].

San Andrés belongs to the drainage basin of the Chicamocha River, whose main tributary is the Guaca River, which crosses through the municipality, dividing it into the following micro-basins: Sisota River, Listará River, Laizgaura River, Congreso River, Guaca River, El Oso Ravine and La Honda Ravine [10].

The Guaca River rises in the Páramo Colorado, its length is 53 km, of which 16.88 km cross the Municipality of San Andrés. This river has as main tributaries the Listará River and Laizgaura Ravine. [7].

The main economic activities that involve the Guaca River’s water source in San Andrés are: Cattle ranching, cheese making processes, agriculture, dairy production, tourism, generation of wastewaters, mineral and rock extraction, goat farming, pig farming, poultry farming, handicraft and guava paste production. The aforementioned activities increase the liquid waste and influence the natural resources of the region [11].

The primary sector focuses on agricultural activities due to the fact that 60% of the land is suitable for cultivation and pasture development, compared to 40% of land that is used for the development of livestock activities, which are focused on the cattle production of milk and meat. The secondary sector focuses on the manufacture of traditional products such as panela, cheese and handmade straw baskets with 41% of the development of the municipality [8]. The economic profitability of the municipality is represented in Figure 1.

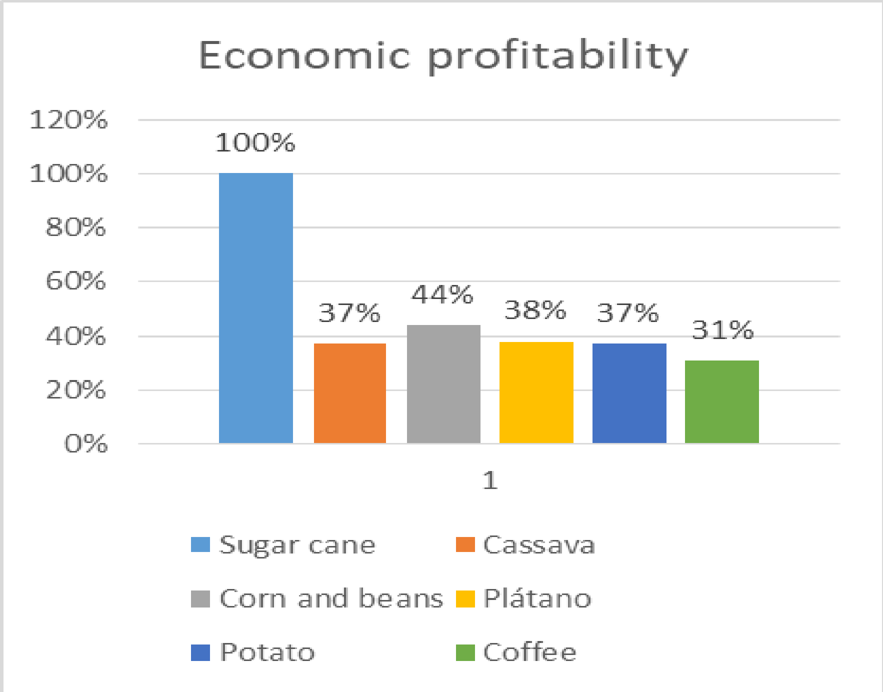


**Figure1**. Economic profitability of San Andrés (Mayor's Office San Andrés, 2020)

**Analysis of COD and BOD5 Upstream and Downstream**

Table 3 presents the analyses obtained in the laboratory for the upstream and downstream samples.

**Table2.** Comparison of upstream and downstream analysis (Own authorship)

| Parameter | Units | Upstream | Downstream |
|---|---|---|---|
| DQO | mgO2/L | <20.0 | <20.0 |
| DBO5 | mgO2/L | 2.9 | 5.8 |

The values of DBO5 exposed in table 9, evidence the increase of the value from this parameter once the discharge is applied to the effluent, since upstream its value was 2.9 mgO2/L and 100 meters downstream of the discharge, the aforementioned value shown an increasement reaching 5.8 mgO2/L.

**Analysis of the physicochemical parameters and their maximum permissible values of domestic sewage.**

Table 4 shows the results of the characterization from Guaca River's discharge in the municipality of San Andrés and the comparison of the analyzes with the maximum permissible limits detailed in Resolution 0631 of 2015.

**Table 3**. Comparative permissible limits and pouring point result (Own authorship)

| Parameter | Units | permissible limit | Analysis |
|---|---|---|---|

| **Parameter** | **Units** | **permissible limit** | **Analysis** |
|---|---|---|---|
| Total coliforms (NMP) | MPN/100mL | Analysis and report | 173290 |
| Total suspended solids | mg/L | 90 | 235.0 |
| Settleable solids | mL/L | 5.0 | 2.0 |
| Fats and oils | mg/L | twenty | 45.8 |
| COD | mgO2/L | 180 | 552.0 |
| BOD5 | mgO2/L | 90 | 289.9 |

The obtained values in the parameter of total coliforms, makes possible the affirmation that the body of water contains a high value of pathogenic microorganisms and organic matter from the animals and humans' feces. Generally, the main bacteria found in the analyzes is the Escherichia coli, which indicates recent contamination due to its survival is limited in enteric environments [12].

Moreover, it is observed that the only evaluated parameter that fulfils the norm is the one regarding the sedimentable solids, the other parameters exceed the allowed limits by the Resolution 0631 of 2015. Which indicates the existence of organic load in the dumping, possibly caused by the dairy production, cheese making and wastes generated in agricultural activities in the region. In the case of total suspended solids, the result gets influenced by faults in the sewage network, specifically in the bypass tank that is not performing its function in an optimal way, limiting the sedimentation of solids with a colloidal load before getting discharged in the Guaca River.

**Identification and evaluation of environmental impacts**

Being aware of the economic activities carried out in the municipality, for identifying the environmental impacts caused in the area; The matrix method was applied, in order to detail the activities likely to produce effects and the environmental components in which changes are generated. The identified impacts are presented in table 5.

**Table 4**. Identification of environmental impacts - Matrix method (Own authorship)

| Activities | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cattle ranching | a | | b | c | d | e | f | | | g | |
| Cheese making processes | | | | | | a | | | | b | |
| Agriculture | a | b | c | d | e | f | g | | | h | |
| Dairy production | | | | | | a | | | | b | |
| Tourism | a | b | c | d | e | f | g | h | | i | |
| Wastewater generation | a | b | c | | d | e | f | | | | g |
| Rock extraction | a | b | c | d | e | f | g | | h | | i |
| Capriculture | a | | b | c | d | e | f | | | g | |
| Pig farming | a | | b | c | d | e | f | | | g | |
| Sandwich production | | | | | | a | | | | b | c |
| Handcraft Elaboration | | | | | | | | | | a | b |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Poultry farming | a | | b | c | d | e | f | | | g | |

References: 1. Flora, 2. Fauna, 3. Landscape, 4. Geomorphology, 5. Soil, 6. Hydrology, 7. Air, 8. Demography, 9. Spatial, 10. Economic, 11. Cultural.

Figure 2 presents the number of alterations caused to the environmental components. It is observed that hydrology and economy are the most affected, since they add up to 11 alterations. Demography and the spatial component are the less affected, presenting just one alteration on each one of them.

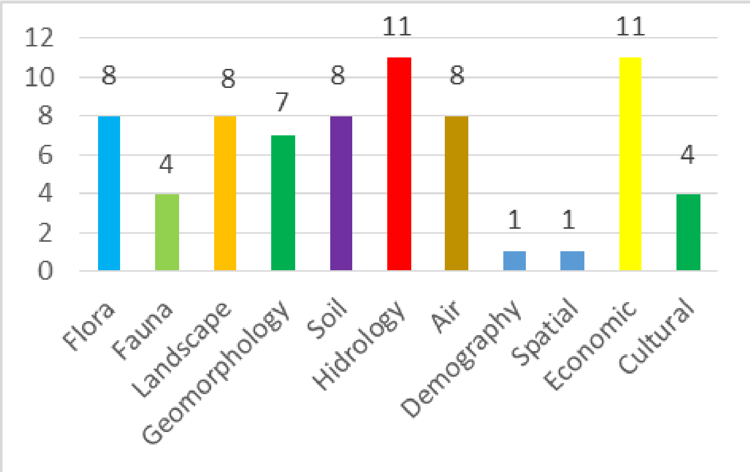


**Figure 2.** Alterations generated by environmental component (Own Authorship)

Once the direct and indirect impacts were identified, the impact assessment was carried out by using the Conesa method, which classifies the most frequent impacts to the environment, taking into consideration their nature, intensity, extension, persistence, recovery activity and cause-effect relationship, among others [14]. In addition, a qualitative assessment is performed to lately qualify identified environmental impact, as observed in Table 6.

**Table 6.** Conesa method impact assessment (Own authorship)

| Impact | |
|---|---|
| Fragmentation of floristic ecosystems | 23 |
| Affectation of forest species | 30 |
| Changes in vegetation cover | 40 |
| Impact on aquatic vegetation | 46 |
| Alteration of faunal communities | 29 |
| Decline and migration of species | 26 |
| Changes in the diversity of the hydrobiological community | 42 |
| Alteration of landscape quality | 28 |
| Changes in the shape of the landscape | 30 |
| Changes in soil geomorphology | 39 |
| Alteration in erosion processes | 42 |
| Loss of soil texture and structure | 37 |
| Changes in land use | 38 |

| Impact | |
|---|---|
| Alteration of the earth's surface | 43 |
| Changes in the physicochemical and microbiological properties of the soil | 23 |
| Water contamination | 62 |
| Changes in the physicochemical and microbiological properties of water | 62 |
| Alteration in the morphology of the water body | 20 |
| Changes in the riverbed | 19 |
| Air pollution | 34 |
| Emission of gases into the atmosphere | 38 |
| Generation of particulate matter | 29 |
| Noise generation | 20 |
| Generation of bad odors | 46 |
| Changes in the demographic component | 49 |
| Increase in visitors to the municipality | 49 |
| Changes in the spatial component | 17 |
| Access and mobility changes | 17 |
| Changes in employment dynamics | 65 |
| Increased income to the population | 65 |
| Generation of social conflict | 18 |
| Problems among the community | 18 |

Figure 3 presents the valuation of impacts according to its importance. It is evidenced, the presence of 4 positive impacts, nine irrelevant impacts, 2 impacts classified as severe and finally 17 moderate impacts, which are the predominant ones [14].

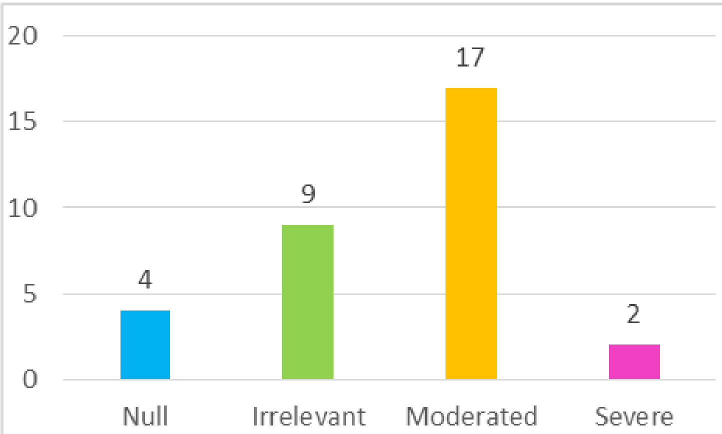


**Figure 3.** Environmental impacts by evaluation criteria (Own authorship)

In like manner, an affirmation can be stated, since the most affected environmental component is the water, due to the fact that severe impacts are directly influencing the quality of the water in the Guaca River. It is important to highlight that the positive nature impacts correspond to the demographic and economic component. Since the economic activities of the region profit the increase in the income of the inhabitants of the municipality. Contributing in this way to the economic development of the region.

## 4. Conclusion

The evaluation of impacts to the Guaca River, allowed to establish the most affected component which is the water one, due to the economic activities from the region; two impacts got categorized as severe. Moreover, the results obtained in the laboratory analyses demonstrate the critical state in which the body of water was found, specifically at the discharging point, where the biodegradability index is close to zero, thus indicating the source of the contaminants present in the water which are organic

The lack of control by the environmental authorities is one of the main factors that influence the affectations to the environmental components, since the lack of evaluation and control allows the development of without the appropiate Colombian environmental regulations, impacting directly the quality and availability of the resources for future generations.

Most of the evaluated parameters in the dumping exceed the permissible limits, indicating that this kind of waste generates an alteration to the water source, that also is affecting the abiotic, biotic and socioeconomic factors.

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