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ENVIRONMENTAL IMPACTS ASSOCIATED WITH PINEAPPLE FARMING IN SANTANDER COLOMBIA

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ABSTRACT

This study evaluated the environmental impact of pineapple cultivation on a property in the El Tabacal in La Mesa de Los Santos. It focused on three specific objectives: to establish an ecological baseline, characterize the impact of the cultivation on a lake in the area of influence, and formulate environmental management strategies. For the study, a methodology combined qualitative approaches through direct observation, analysis of secondary data, and unstructured interviews with residents; the quantitative approach includes analyzing the water's physicochemical parameters and surveys to define the community's perception regarding cultivation. The results obtained show that anthropic activities alter the ecosystem, introduced vegetation predominates, and thermotolerant microorganisms were found in the lake. The index of biodegradability of water contaminants is also low.

KEYWORDS: Pineapple cultivation, environmental impacts, pollution, sustainable development

2.1.1. Parameters and methods analyzed

Nine physicochemical and microbiological parameters were analyzed. The selection of these parameters, although it does not include the analysis

of other more specific parameters due to their high costs, those analyzed in this study provide sufficient and reliable information on water quality. The parameter analyzed and the method used for its respective analysis as shown in Table 1.

Table 1: Caption of the table.

Parameter	Method
BOD ₅	Incubation for 5 days, optical electrode (SM 5210 B; 4500-O H)
COD	Closed and Volumetric Reflux (SM 5220 C)
Total reactive phosphorus (Read as orthophosphates)	Ascorbic acid (SM 4500-P B Inciso 1, SM 4500-P E)
Nitrates	Molecular absorption spectrometry
Dissolved oxygen	Membrane electrode (SM 4500-O G)
Total dissolved solids	Gravimetric (SM 2540 C)
Turbidity	Nephelometric (M 2130 B)
Thermotolerant coliforms (fecal)	Fermentation in multiple tubes (SM 9221 E)
Total coliforms	Multi-cell enzyme substrate (SM 9223 B)

2.2. Identification and evaluation of environmental impacts

The environmental impacts in the area of influence of the crop were identified through fieldwork, analyzing the 13 main activities carried out in the pineapple cultivation process: land preparation (cleaning and plowing), application of chicken manure as fertilizer, planting of pineapple shoots or crowns, irrigation of the crop, weed control, application of chemical fertilizers, pest and disease control, fruit harvest, fruit harvest, management of crop residues, temporary storage of the fruit in the field, transportation of the harvest, handling, and disposal of agrochemical containers, maintenance of agricultural machinery and equipment. Also, some interviews were conducted with residents and pineapple farmers. This comprehensive approach helped to better understand how people's actions affect the different components of the water source. Based on the above, ASPI (Actions Susceptible to Produce Impacts) were identified. Subsequently, for each identified activity, their possible interactions with the environmental components were analyzed and then FARI (Environmental Factors Representative of the Impact) were defined, taking into account the indicators and their units in such a way that it was possible to define the direct and indirect environmental impacts.

The method by which the environmental impact assessment was carried out was that of Conesa, this method was developed by Vicente Conesa Fdez-Vitora. This method provides a systematic and quantitative approach to assess the importance of environmental impacts in projects or activities [4]. Therefore, it was very useful for the development of this study that, first, numerical

values were assigned to a series of criteria that characterize the environmental impact (extent, moment, persistence, reversibility, synergy, accumulation, effect, periodicity, recovery capacity). These values were inserted into a formula that yielded a number, known as "Importance of Impact" (I). Secondly, each attribute was rated with a number according to scales that are already predetermined in the Methodological Guide for the evaluation of environmental impact. Next, the importance of impact (I) was calculated using the following Equation 1.

$$I = \pm [3i + 2EX + MO + PE + RV + SI + AC + EF + PR + MC] \tag{1}$$

Furthermore, the results of the importance of the impact are represented by colors, taking into account the Hierarchy of the importance of the environmental impact of the Conesa Methodology, as described in Table 2:

Table 2: mportance of environmental impact.

Category	Identification
Irrelevant	Less than 25
Moderate	Between 25 and 50
Severe	Between 50 and 75
Critical	Over 75
Zero impacts	Zero impacts

3. RESULTS AND DISCUSSION

3.1. Environmental Impact Assessment

The Environmental Impact Assessment was carried out using the Simplified Conesa method, which identified, assessed, and classified the

environmental impacts generated in the study area. A matrix was used to evaluate the magnitude and importance of each impact, considering physical, biological, and social factors, and the results are shown in Table 3.

Table 3: Matrix on the evaluation of environmental impacts by the Simplified Conesa method.

Environmental Impact	NAT	IN	EX	MO	PE	RV	SI	AC	EF	PR	MC	IMP	Assessment
Soil erosion	-	8	4	4	2	4	4	4	4	4	4	62	Severe
Alteration of soil quality	-	8	4	4	2	4	4	4	4	4	4	62	Severe
Loss of soil fertility	-	8	4	4	4	2	4	4	4	4	4	62	Severe
Increased concentration of salts in the soil	-	4	4	4	2	4	2	2	4	4	4	46	Moderate
Soil saturation	-	2	2	2	2	1	2	1	4	1	1	24	Irrelevant
Soil compaction	-	8	4	4	2	2	4	4	4	4	4	60	Severe
Solid waste generation	-	2	4	4	2	1	1	1	1	2	4	30	Moderate
Disturbance of soil drainage	-	4	4	4	2	4	4	4	4	4	4	50	Severe
Change in soil structure	-	8	4	4	2	2	4	4	4	4	4	60	Severe
Impact on tourism	-	2	2	2	2	2	1	1	2	1	1	22	Irrelevant
Alteration of the landscape	-	8	8	4	4	2	4	1	4	4	2	65	Severe
Changes in the microclimate	-	2	2	4	2	2	1	1	1	2	1	24	Irrelevant
Increase in greenhouse gases	-	2	2	4	1	1		1	4	1	2	24	Irrelevant
MP Generation	-	2	2	4	1	1	1	1	4	1	2	25	Moderate
Methane emission	-	2	2	2	1	1	1	1	1	2	2	21	Irrelevant
Deteriorating air quality	-	2	2	2	2	1	1	4	1	1	1	23	Irrelevant
Emission of offensive odors	-	8	12	2	1	1	1	4	4	4	2	67	Severe
Increase in pesticide use	-	8	8	2	1	1	1	4	4	4	2	59	Severe
Impact on human health	-	2	2	2	1	1	1	1	1	2	1	20	Irrelevant
Alteration of the physicochemical characteristics of water	-	8	4	2	2	4	4	4	4	4	2	58	Severe
Greenhouse gas emissions	-	2	2	2	1	1	1	1	4	2	2	24	Irrelevant
Disruption of the food chain	-	4	4	4	2	2	2	4	4	2	4	44	Moderate
Reduction of ecosystem services	-	8	4	4	2	2	2	4	4	2	4	56	Severe
Loss of topsoil	-	8	4	4	4	2	1	4	4	4	3	58	Severe
Affectation of the flora	-	8	4	4	4	4	2	4	4	2	4	60	Severe
Attraction of insects and pests	-	8	12	4	4	1	1	4	4	4	4	74	Severe
Water pollution	-	8	8	4	2	2	4	4	4	4	4	68	Severe
Conflicts over water use	-	4	4	2	2	2	4	2	1	4	4	41	Moderate
Ecosystem alteration	-	4	2	2	4	2	2	4	1	2	1	34	Moderate
Water Depletion	-	8	4	2	4	4	2	2	4	2	4	56	Severe
Disturbances to the community	-	8	4	2	4	4	4	4	1	1	1	53	Severe
Risks to human health	-	8	4	1	2	2	4	4	1	1	2	49	Moderate
Development of the transport sector and local markets	+	2	2	2	2	2	2	4	1	1	2	26	Null
Dependence on external inputs	-	2	1	1	2	1	2	1	1	1	1	18	Irrelevant
Increased Production Costs	-	4	1	2	4	1	4	4	1	2	1	33	Moderate
Job creation	+	2	1	4	4	2	2	1	1	1	1	24	Null
Increase in the local economy	+	2	2	1	2	1	2	1	1	1	1	20	Null
Improving the quality of life	+	2	2	1	1	1	2	1	1	1	1	19	Null
Changes in local demographics	-	2	1	2	4	2	2	1	1	1	1	22	Irrelevant
Increased revenue	+	2	2	1	1	1	4	1	1	1	1	21	Null
Changes in the social structure	-	2	1	2	4	2	2	1	1	1	1	22	Irrelevant
Alteration of cultural patterns	-	2	1	1	2	1	2	1	1	1	1	18	Irrelevant
Changing agricultural practices	-	2	1	1	2	1	2	1	1	1	1	18	Irrelevant
Land use change	-	2	2	2	4	1	2	1	1	1	1	23	Irrelevant

The most severe impacts are concentrated in soil degradation (see Table 3), including compaction,

erosion, loss of soil fertility, alteration of soil quality and loss of the topsoil. Other major severe and

moderate impacts are related to water pollution, alteration of the physicochemical characteristics of water, depletion of water resources, and conflicts over water use. On the other hand, the biotic component is moderately impacted, and is related to the reduction of ecosystem services and their alteration, the affectation of flora and the attraction of insects and pests, which represents a significant alteration of the biodiversity and ecological balance of the study area of influence. In addition, the emission of offensive odors also affects the air, for this reason, there is a severe impact related to the inconvenience to the community. On the other hand, in the analysis of the importance of the impacts, it is

observed that the irrelevant impacts have to do with changes in the microclimate, deterioration of air quality, greenhouse gas emissions, and changes in local demographics, among others, within which the increase in income, improvement of the quality of life, job creation, growth of the local economy, and the development of the transportation sector and local markets are of a positive nature.

Taking into account the data presented in Figure 2, and the color classification, the number of environmental impacts and their importance can be determined, according to the Conesa methodology.

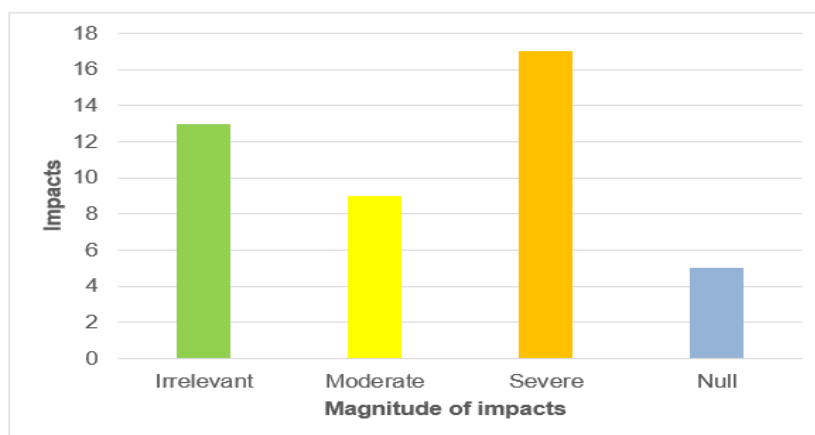


Figure 2: Number of impacts and their assessment according to importance

Figure 2 displays the evaluation of the environmental impacts related to pineapple cultivation, which is classified into three levels of severity: irrelevant, moderate, and severe. In this study, no critical or null impacts were identified. The category with the greatest number of impacts is "Irrelevant", with 13 interactions, therefore suggesting that the majority of the impacts evaluated minimally affect the environment, such as increasing the quality of life, job creation, increased income, and change in local demographics.

Additionally, the interactions classified as "Severe" were a total of 17, which worryingly indicates that some activities within the pineapple cultivation

process have strong negative effects on the environment. The impacts identified as severe have a significant degree of importance concerning the soil, water, and air quality resources, therefore they can have serious effects on the ecosystem and the local community. The category with the least serious impacts is "Moderate", with 9 interactions, therefore it is important to develop mitigation measures to prevent these impacts from generating greater damage to the environment.

3.2. Characterization of the water source

Figure 3 shows the image of the lake under study, located in the area of influence of pineapple cultivation in the Tabacal village.



Figure 3 and 4: Lake where monitoring was carried out (left); pineapple cultivation (right)

The results of the physicochemical and microbiological analysis are seen in table 24, these indicate relevant information about water quality and

suggest possible impacts of pineapple cultivation on this resource.

Table 4: Results of laboratory analysis sampling parameters

Analysis	Units	Result	Allowed limit	Resolution that applies	Applies (Yes/No)
BOD ₅	mg/L	3.20	50	631/2015	Yes
COD	mg O ₂ /L	40.3	150	631/2015	Yes
Total reactive phosphorus (read as orthophosphates)	mg PO ₄ -3/L	0.230	0,5	2115/2007	Yes
Nitrate	mg NO ₃ -N/L	0.376	10	2115/2007	Yes
Turbidity	NTU	45	2	2115/2007	No
Total coliforms	NMP/100mL	6488	Absence	2115/2007	No

Table 4 reflects the results obtained from the physicochemical and microbiological analyses taken from the lake water sample. These reveal important aspects about its quality and the possible impact of pineapple cultivation. The BOD₅ and COD comply with the limits established in Resolution 631 of 2015, indicating a moderate organic load. It should be noted that there is no discharge of domestic wastewater, but the load is the result of surface runoff that carries organic fertilizers, in this case chicken manure. The parameters were analyzed given their importance in determining the biodegradability index. The parameters related to nutrients analyzed, such as total reactive phosphorus and nitrates, are also within the limits established according to Resolution 2115 of 2007, evidencing an adequate dosage level in the use of fertilizers. However, the study revealed two critical parameters that do not comply with the parameters established in the regulations; As for turbidity and total coliforms, both exceeded the limits established in Resolution 2115 of 2007. Therefore, they suggest that there is an impact on water quality, possibly related to surface runoff from agricultural activities, particularly with the application of unstabilized chicken manure on

pineapple crops.

3.2.1. Other important parameters analyzed

Dissolved oxygen in water is a parameter that indicates the amount of oxygen present in the water and required to sustain life in it. Dissolved oxygen is one of the parameters of water treatment, and is affected by the level of pollution in the water body. Aquatic life depends on the amount of dissolved oxygen, since invertebrate organisms need oxygen to breathe. This parameter is closely related to climatic elements such as temperature and atmospheric pressure, as well as the concentration of organic matter present in the water source. When dissolved oxygen levels are very low, there is an unfavorable environment for aquatic life, and with this, phenomena such as eutrophication occur, generated by the proliferation of algae, which minimize the supply of oxygen in the water source. Dissolved oxygen is essential to determine water quality, the concentration must be below 110% and is related to atmospheric pressure in an indirectly proportional way □5□. The result of this parameter is shown in Table 5.

Table 5: Dissolved oxygen result in laboratory

Analysis	Unit	Result
Dissolved oxygen	mg/L de O ₂	2.76

The dissolved oxygen (DO) measured in the lake water sample, as shown in Table 5, presented a value of 2.76 mg/L of O₂. Although this parameter is not regulated in the applicable environmental regulations, it is a fundamental indicator to evaluate the quality of the aquatic ecosystem. The concentration of dissolved oxygen found is low compared to the levels typically necessary to maintain healthy aquatic life. This result could be related to the presence of organic matter and nutrients from pineapple cultivation in the area, since these components require oxygen for their decomposition. The level of dissolved oxygen

observed is a relevant indicator to understand the degree of influence of agricultural activities on the body of water.

In the total dissolved solids there are: salts, metals, organic matter, cations and anions that dissolve in water, likewise in these dissolved solids there are elements such as calcium, magnesium, sodium, potassium, bicarbonates, chlorides and sulfates. This is a parameter that represents water quality; International standards stipulate that the value must be less than 500 mg/L, if the water evaluated is for human consumption, since this influences the taste, hardness and corrosiveness of

the water; while for plant irrigation if it has high levels, it can affect the health of the plants and the

soil [6]. The result of this parameter is shown in Table 6.

Table 6: Total dissolved solids result in laboratory

Analysis	Unit	Result
Total dissolved solids	mg/L	158

Table 6 shows that the water sample analyzed gave a result of 158 mg/L. Although this parameter is not specifically regulated in current environmental regulations, this measurement is essential to evaluate the impact of pineapple cultivation on the monitored lake. TDS can indicate the presence of mineral salts and inorganic compounds from fertilizers and agrochemicals used in cultivation, which reach the lake through runoff or leaching. The result obtained suggests the existence of contributions of dissolved substances that could be related to agricultural activities around the water source. This result, together with other physicochemical parameters, contributes to shed light on the influence of pineapple cultivation on the quality of lake water, since TDS can affect aquatic life and modify the natural characteristics of the aquatic ecosystem.

Thermotolerant fecal coliforms are a type of coliform with the characteristic of being able to resist high temperatures, and their reproduction can occur at 44°C, in this way they are differentiated from other coliforms; Escherichia coli belongs to this group. The finding of these bacteria in lake water determines contamination by fecal matter of human or animal origin, which causes diseases and indicates that the water is not suitable for human consumption; this occurs in organically enriched waters. This parameter identifies if there is a flow that contains more than 125 kg/day of BOD5. It is assumed that there should be no thermotolerant coliforms in a 100 ml sample of drinking water [7]. The result of this parameter is shown in Table 7.

Table 7: Laboratory results of thermotolerant fecal coliforms

Analysis	Unit	Result
Thermotolerant fecal coliforms	NMP/100mL	4.5

The result observed in Table 7 reveals the presence of thermotolerant microorganisms in the lake. Although not specifically regulated in current environmental regulations, this parameter value reflects crucial information about water quality and a risk to human health. These microorganisms, resistant to higher temperatures, are typically indicators of fecal contamination, which suggests that the lake could be receiving loads of organic matter

from animal excrement that have not gone through an adequate physical, chemical and bacteriological stabilization process [8]. Without adequate treatment, this waste can introduce bacteria, viruses and other pathogens into bodies of water, affecting both aquatic ecosystems and people who come into contact with the water or use it for agricultural activities.

3.3. Biodegradability Index

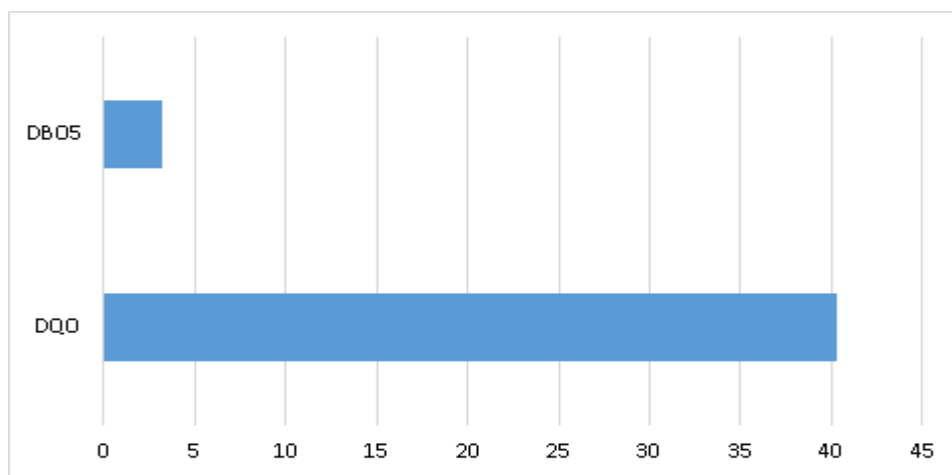


Figure 5: Biodegradability Index

The biodegradability index (BI) is determined by the relationship between the Biochemical Oxygen Demand (BOD) and the Chemical Oxygen Demand

(COD), the biodegradability criteria are shown in the Table 7 and the calculation is expressed in Equation 2.

Table 8: Biodegradability criteria BOD5/COD

BOD ₅ /COD	Criteria
>0.8	Highly biodegradable
0.7 - 0.8	Biodegradable
0.3 - 0.7	Little biodegradable
<0.3	No biodegradable

$$\frac{3.20}{40.3} = 0.079 \quad (2)$$

As seen in Figure 3, there is a large difference between the biochemical oxygen demand and the chemical oxygen demand. According to this result, it indicates that the analyzed sample is “non-biodegradable” since it is less than 0.3 [9], compared to the values defined in Table 8. The analysis of this value suggests that the compounds present in the water or waste studied present difficulty in degradation by biological action, which implies that the material has a low capacity to be decomposed by microorganisms. This result is worrying from an environmental point of view, since a low biodegradability index indicates that the identified contaminants could persist in the environment for long periods, possibly affecting water quality and ecosystems. The presence of non-biodegradable compounds could also require more intensive and expensive treatments for their elimination, hence the need to identify them and mitigate the sources of these contaminants [10].

4. CONCLUSIONS

The environmental impacts generated by pineapple cultivation were evaluated using the environmental impact assessment matrices of the Simplified Conesa method, establishing that there is impact on the soil due to erosion, compaction and loss of vegetation cover, given the requirements of pineapple cultivation. According to Obando [1], an impact is also observed on the biotic component, with a progressive decrease in the native flora and the displacement of local fauna, which affects biodiversity and ecological balance due to the

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alteration in the trophic chain, this leads to the excessive growth of species on the one hand, and a decrease in others. In addition, it allowed critical points to be identified and facilitated the formulation of strategies to mitigate environmental impacts and a sustainable balance between agricultural productivity, socioeconomic development and the conservation of natural resources.

The water of the lake located in the area of influence of the pineapple crop was characterized, resulting in turbidity and total coliforms not meeting the permissible limits of current environmental standards for water quality. According to [11], this problem could be related to the type of organic fertilizer applied to the pineapple crop, which is carried by runoff from rain to the lake, as well as by another climatic element such as wind. This is why it is necessary to improve crop practices, to avoid putting at risk the availability of optimal water for agricultural work and for the community in the future.

Use of AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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Conflict of interest

We declare that there are no conflicts of interest of any kind.

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