Conciencia Digital

ISSN: 2600-5859
Vol. 7 No. 3.2, pp. 17 – 33, September 2024

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Análisis de dispersión de la contaminación en cuerpos de agua por lixiviados, provenientes del botadero de basura Curgua, Guaranda - Ecuador

Analysis of pollution dispersion in water bodies by leachates from the Curgua garbage dump, Guaranda – Ecuador

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Scientific and Technological Research Article
Sent: 10/07/2024
Revised: 08/08/2024
Accepted: 02/09/2024
Published: 09/13/2024
DOI:**https://doi.org/10.33262/concienciadigital.v7i3.2.3176**

Please quote:

Torres Murillo, KJ, & Gaibor Chávez, J. (2024). Dispersion analysis of contamination in water bodies by leachates from the Curgua garbage dump, Guaranda - Ecuador. ConcienciaDigital, 7(3.2), 18-33.https://doi.org/10.33262/concienciadigital.v7i3.2.3176

DIGITAL CONSCIOUSNESS,*and*It is a multidisciplinary, quarterly journal, which will be published electronically. Its mission is to contribute to the training of competent professionals with a humanistic and critical vision who are capable of presenting their research and scientific results to the same extent that their intervention promotes positive changes in society.https://concienciadigital.org
The journal is published by Editorial Ciencia Digital (a prestigious publisher registered with the Ecuadorian Book Chamber with membership number 663).www.celibro.org.ec

Palabras claves:
Lixiviados, contaminación agua, índice calidad agua

Resumen

Introducción: la disposición final de residuos sólidos municipales constituye una problemática ambiental y sanitaria actual. **Objetivo:** el objetivo de la investigación fue analizar la dispersión de la contaminación en cuerpos de agua, por los lixiviados provenientes del botadero de basura denominado Curgua, Cantón Guaranda – Ecuador. **Metodología:** las muestras de agua se recolectaron en diferentes puntos: al ingreso al cuerpo de agua dulce localizado a 60 m de la fuente que constituye el punto 2; luego a 500 m, 1.5 km, 2 km y 3 km. El análisis se realizó por triplicado durante 3 semanas. Se realizaron análisis físico - químicos de acuerdo con la metodología de la empresa HACH. Se determinó la dinámica de la concentración de los principales compuestos de acuerdo con los puntos de muestreo. **Resultados:** se presenta los valores de los principales estadísticos de los parámetros de calidad analizados, el promedio, desviación estándar, coeficiente de variación. Se encontró que a medida que aumenta la distancia del punto de origen los valores de los parámetros disminuyen parcialmente, pero aún persisten, lo que provoca la constante presencia de contaminación en el cuerpo de agua dulce. **Conclusiones:** existe una correlación entre algunos parámetros, esto se debería por el tipo y composición físico química y biológica de los residuos que se generan. Este hecho incrementa el riesgo de mantener e incluso aumentar la contaminación en épocas en las que se puede influir directamente en la generación de residuos sólidos. **Área de estudio general:** Ciencias del Ambiente. **Área de estudio específica:** Manejo y disposición de residuos. **Tipo de estudio:** Artículo original

Keywords:
Leachate, water pollution, water quality index, water quality index

Abstract

Introduction:the final disposal of municipal solid waste is a current environmental and sanitary problem. Objective: the objective of the research was to analyze the dispersion of contamination in bodies of water by leachates from the Curgua garbage dump, Canton Guaranda - Ecuador. Methodology: water samples were collected at different points: at the entrance to the freshwater body located 60 m from the source, which is point 2; then at 500 m, 1.5 km, 2 km and 3 km. The analysis was carried out in triplicate for 3 weeks. Physical-chemical analyzes were performed according to HACH methodology. The dynamics of the concentration of the main compounds was determined according to the sampling points. Results: the values of the main statistics of the quality parameters analyzed the average, standard deviation and coefficient of variation are presented. It was found that as the distance from the point of origin increases, the values of the parameters decrease partially, but persist, which causes the constant presence of contamination in the freshwater body. Conclusions: There is a correlation between some parameters, due to the type and physical, chemical and biological composition of the waste generated. This fact increases the risk of maintaining and even increasing pollution in times when the generation of solid waste can be directly influenced. General area of study: Environmental Sciences. Specific area of study: Waste management and disposal. Type of study: Original article

Introduction

The presence of municipal solid waste generates a high concentration of toxic substances in liquids derived from the decomposition of waste, which constitutes a constant risk to human health and the environment (Murcia et al., 2020). The management and disposal of urban solid waste is a constant problem that municipalities in Ecuador must face. The National Program for the Comprehensive Management of Solid Waste (PNGIDS) has been created (Vaca, 2020). Which has specific objectives to reduce and take advantage of waste at all stages of the process (United Nations Organization [UN], 2019], andthe implementation of policies for waste reduction, with the aim of eliminating landfills (Gila, 2022), ayes, as well as promoting the use of reusable, repairable and recyclable materials to reduce the environmental impact (Cando & Arguello, 2021), which coincides with all fiscal, ecological and biological issues that develop due to the uncontrolled increase in the population (Rodríguez, 2023). Urban solid waste landfills are identified as the main threats to underground water resources (Lascano, 2020). Such as solid remains that are deposited in landfills or open-air dumps that can be affected by groundwater overflow and infiltration of precipitation or other forms of water entry (León & Andrade, 2021). Landfill leachates, when infiltrating into surface and groundwater, can introduce a variety of chemical compounds and dissolved materials that pose a risk to the community (Espinoza-Quispeet al., 2020). However, since all dumps or landfills are sites where garbage is disposed of inappropriately without receiving any properly sanitary method, it is considered contamination in the formation of leachate (Fernandez-CortesThe leachate liquid results from the drainage process of a landfill that filters through a solid (Cardenas-Ferreret al., 2020), coming from the rains, the humidity of the solid waste and decomposition of by-products (Morales, 2021), by which this liquid is defined as inflation of water that passes through the underground soil carrying with it the dissolved waste components of the biochemical reaction that constitutes a danger to the environment (Podlasek, 2023). The compounds of various materials that act in the composition of leachates are influenced by extreme environmental aspects (age of the landfill, technology used in the plant) and aspects of the nature of the waste itself (pH, age, temperature) (Pozo et al., 2020). The variable composition of this liquid depends mainly on the phases of solid waste and the age of the landfill (Cuichán, 2022), likewise its solid waste is represented as rejection because it cannot be handled properly (Raza-Carrillo & Acosta, 2022).The contaminated liquid from this waste that filters from a landfill, known as leachate, has a composition that can vary considerably depending on the age of the landfill and the type of waste it contains (Becerra-Morenoet al., 2022),These wastes are defined by having higher concentrations of COD (Chemical Oxygen Demand), BOD (Biological Oxygen Demand), ammonium and alkalinity, a high BOD/COD ratio (Luo et al., 2020).This variability evolves in the quantity and composition of the waste that depends on the level of compaction of the initial humidity of the garbage, the type of covering material, rainfall, temperature, evaporation, infiltration and the field capacity of the landfill are determining factors in the management and disposal of solid waste (Poblete et al., 2019). The volume of leachates generated by these wastes is based on each of their components, giving rise to different formulations for their application, however there are environmental problems of landfills with greater influence on the disposal of places with urban solid waste (Pellonet al., 2009), as well as the infiltration of leachates into surface and groundwater with contaminating liquids in landfills must be treated before being dumped on a surface (Espinosa, 2023). For this reason, it is necessary to establish the most appropriate treatments to reduce and recycle waste (Huang et al., 2019), with a focus on effective treatment to mitigate its negative impact on the environment (Cardenas-Ferreret al., 2019), such as preventing the production of toxic waste and waste formation with changes in consumption habits and creative reuse of products that may generate garbage or pollutants (Vidarte & Colmenares, 2020).

Methodology

This research adopted an observational and analytical methodological approach to assess the impact of leachate generated in the Curgua sector on a nearby freshwater body. Systematic sampling was implemented at the leachate source and at strategic points along the water body, allowing the analysis of the dynamics of contamination at different distances. The physical-chemical analyses carried out with the provided quantitative data

ISSN: 2600-5859
Vol. 7 No. 3.2, pp. 17 – 33, September 2024

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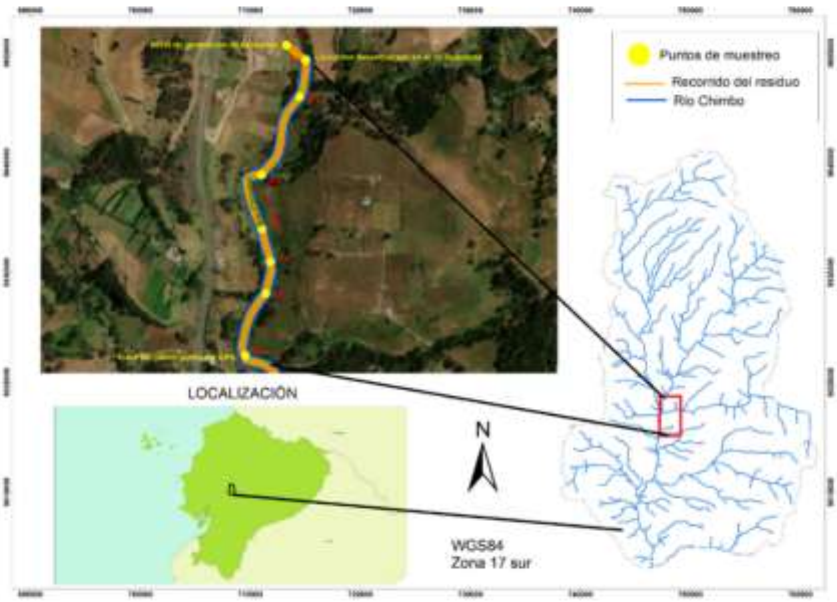
on the concentration of key contaminants, while the statistical analysis allowed the interpretation of the evolution of contamination and the establishment of relationships between the variables studied. The study was carried out in the Curgua sector, Santa Fe Parish – Guaranda Canton – Ecuador. The leachate produced directly at the source was analyzed. Water samples were collected at different points: at the entrance to the freshwater body located 60 meters from the source, which constitutes point 2; then at 500 m, 1.5 km, 2 km and 3 km. The analysis was carried out in triplicate for 3 weeks. The analyses were carried out according to the methodology of the company HACH. They were carried out onlyrapid physical-chemical analysis to avoid alteration of the results. The dynamics of the concentration of the main compounds was determined according to the sampling points. Statistical analysis of the data was performed.

Figure 1

Sampling points



The water quality index was calculated according to the methodology developed by Abbasi & Abbasi (2012). It proposes a relationship between the measured values of the parameters and the natural levels of the parameter. It is mainly based on a weighted arithmetic sum aggregation method, which transforms the values by means of functional curves produced by the Delphi method.

$$ICA = \sum_{i=1}^{n} w_i * SI_i (1)$$

Where$wi$is the relative weight of parameter i, n is the number of parameters used (in this case 11) and$SIi$is the quality subindex of parameter i. This index includes a wide range of contaminants, pH, dissolved oxygen and BOD. pH is associated with the toxicity levels

Conciencia Digital
ISSN: 2600-5859
Vol. 7 No. 3.2, pp. 17 – 33, September 2024
www.concienciadigital.org

of different contaminants. However, dissolved oxygen is directly associated with the dynamics of life in the ecosystem (Tambo, 2015). Nitrates and phosphates are also considered to assess the presence of nutrients. Finally, it takes into account the biochemical oxygen demand since this can function as an indicator of contamination by organic matter (Boyacioglu, 2007). Table 1 shows the relative weights of the NSF quality index.

Table 1

Relative weights

Quality parameter	*wi*
pH	0.11
Dissolved solids	0.07
Electrical conductivity	0.11
Dissolved oxygen	0.17
BOD	0.11
Total hardness	0.1
Chlorides	0.1
Ammoniacal nitrogen	0.1
Total phosphates	0.1
Color	0.11
Turbidity	0.07

Fountain: Taken from 'Conventional' Indices for Determining Fitness of Waters for Different Uses Abbasi & Abbasi (2012).

After determining the quality index for the sampling point, it must be compared with the water quality classification ranges, where the following must be observed:

Table 2

Ratings and criteria

Range	Classification
0-25	Very bad
26-50	Bad
51-70	Average
71-90	Good
91-100	Excellent

Water quality data is made known using a rating scale.

Conciencia Digital
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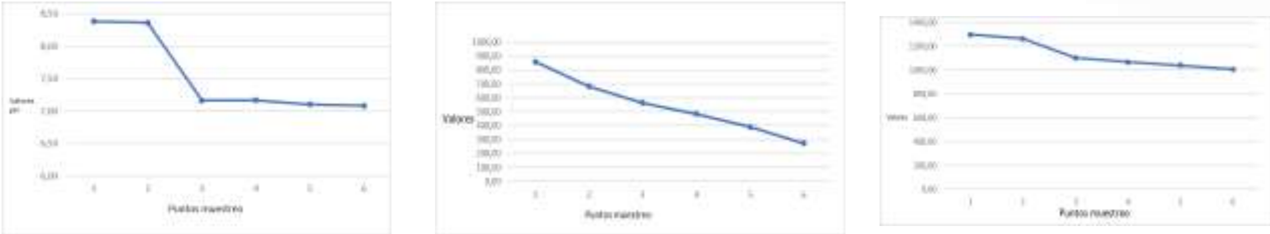
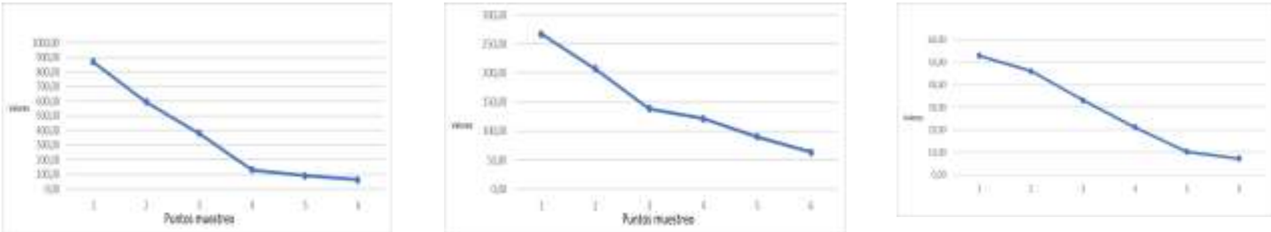
Figure 2

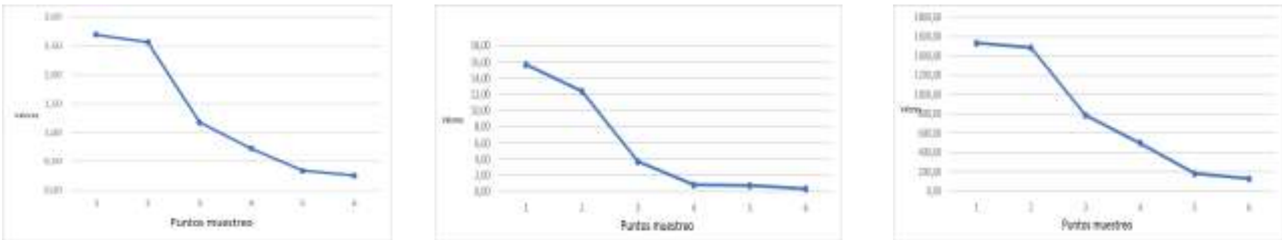
Dynamics of water quality parameters



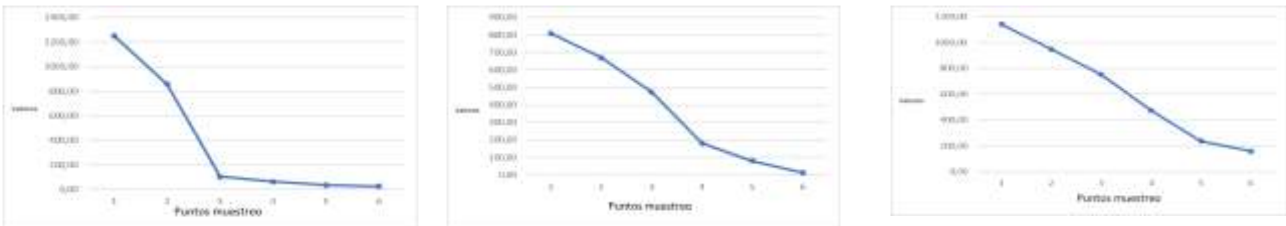
a) pH b) Dissolved solids c) Conductivity



d) BOD5 e) Total hardness f) Dissolved oxygen



g) Phosphates h) Ammoniacal nitrogen i) Chlorides



j) COD k) Turbidity l) Colour

Conciencia Digital
ISSN: 2600-5859
Vol. 7 No. 3.2, pp. 18 – 33, September 2024
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The water quality parameters measured at different points and at different distances are presented.

Table 3

Water quality parameters at different sampling points

Parameter / Sampling point	Statistical	Color	Turbidity	pH	Conductivity	Total solids Dis.	Temperature	Total Nitrogen	Phosphates	Ammoniacal Nitrogen (NH3-N)	Sulfates	Fluorides	Total iron	Manganese	Chrome
Point 1	Average	1140.43	808.32	8.38	1299.57	859.61	19.30	41.00	2.70	15.70	15,10	15.57	7.96	0.41	0.84
	Minimum	1087.35	808.23	7.85	1278.25	855.89	18.70	40.95	2.60	15.65	15.06	15.45	7.90	0.40	0.78
	Maximum	1178.93	808.36	8.90	1315.27	862.69	19.80	41.08	2.84	15.76	15,12	15.65	8.00	0.42	0.88
	CV	0.04	0.00	0.06	0.01	0.00	0.03	0.00	0.05	0.00	0.00	0.01	0.01	0.02	0.06
	Dest	47.50	0.07	0.53	19,14	3.44	0.56	0.07	0.13	0.06	0.03	0.10	0.05	0.01	0.05
Point 2	Average	948.67	670.12	8.37	1263.26	684.08	18.40	31.84	2.57	12.39	13.77	12.03	6.61	0.21	0.75
	Minimum	941,00	668.22	8.32	1240.56	675.26	18,20	31.56	2.51	12,18	13.50	11.98	4.61	0.20	0.74
	Maximum	955,00	672.15	8.40	1274.89	689.42	18.60	32,00	2.62	12.76	14.00	12,10	7.63	0.22	0.75
	CV	0.01	0.00	0.00	0.02	0.01	0.01	0.01	0.02	0.03	0.02	0.01	0.26	0.05	0.01
	Dest	7.09	1.97	0.04	19.66	7.69	0.20	0.24	0.06	0.32	0.25	0.06	1.74	0.01	0.01
Point 3	Average	751.30	473.61	7.16	1103.40	563.46	17.37	24.57	1.18	3.69	10.73	8.47	5.49	0.15	0.61
	Minimum	747.12	473.12	7,12	1103.11	560.24	17.20	24,12	1.12	3.62	10.73	8.46	5.48	0.14	0.60
	Maximum	754.20	474.25	7.22	1103.84	567.03	17.60	24.95	1.23	3.74	10.74	8.48	5.51	0.15	0.62
	CV	0.00	0.00	0.01	0.00	0.01	0.01	0.02	0.05	0.02	0.00	0.00	0.00	0.04	0.02
	Dest	3.71	0.58	0.05	0.39	3.41	0.21	0.42	0.06	0.06	0.01	0.01	0.02	0.01	0.01
Point 4	Average	473.90	180.91	7.17	1068.19	485.37	17.30	15.42	0.73	0.81	8.23	5.34	3.48	0.10	0.38
	Minimum	468.39	180.14	7.15	1068.15	484.22	17,24	15,22	0.71	0.80	8.22	5.33	3.47	0.10	0.37
	Maximum	478.22	182.12	7.18	1068.23	486.23	17.40	15.75	0.75	0.83	8.24	5.35	3.49	0.11	0.38
	CV	0.01	0.01	0.00	0.00	0.00	0.01	0.02	0.03	0.02	0.00	0.00	0.00	0.06	0.02
	Dest	5.02	1.06	0.02	0.04	1.03	0.09	0.29	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Point 5	Average	236.68	79.41	7,10	1039.91	391.05	17,19	7.37	0.34	0.73	7.32	2.02	1.13	0.05	0.16
	Minimum	231.22	78.96	7.09	1038.74	390.58	17.02	7.15	0.31	0.72	7.29	2.02	1.12	0.05	0.15
	Maximum	245.67	79.74	7,12	1040.78	391.36	17.50	7.69	0.36	0.74	7.34	2.03	1.14	0.05	0.16
	CV	0.03	0.01	0.00	0.00	0.00	0.02	0.04	0.07	0.01	0.00	0.00	0.01	0.00	0.04
	Dest	7.84	0.40	0.02	1.05	0.42	0.27	0.29	0.03	0.01	0.03	0.01	0.01	0.00	0.01
Point 6	Average	159.24	12.63	7.08	1006.77	273.05	17.02	5.23	0.26	0.30	5.13	1.42	0.78	0.03	0.10
	Minimum	152.32	12.43	7.08	1002.33	272.36	17.01	5.09	0.22	0.30	5,12	1.41	0.78	0.03	0.10
	Maximum	163.21	12.80	7.09	1009.25	273.95	17.02	5.38	0.28	0.31	5.14	1.42	0.79	0.03	0.11
	CV	0.04	0.01	0.00	0.00	0.00	0.00	0.03	0.13	0.02	0.00	0.00	0.01	0.00	0.06
	Dest	6.01	0.19	0.01	3.86	0.82	0.01	0.15	0.03	0.01	0.01	0.01	0.01	0.00	0.01

Parameter / Sampling point 3	Statistical	Copper	Total hardness	Aluminum	Chlorides	Nickel	Lead	Zinc	Silver	Cyanide	Barium	Bromine	Molybdenum	Dissolved oxygen	BOD5	COD
Point 1	Average	0.64	267.10	0.14	1531.16	0.79	0.01	0.86	0.01	0.36	2.60	0.00	0.00	52.95	869.55	1251.41
	Minimum	0.62	265.65	0.13	1528.13	0.78	0.01	0.84	0.01	0.32	2.58	0.00	0.00	52.84	867.96	1249.64
	Maximum	0.66	269.30	0.14	1535.14	0.81	0.01	0.88	0.01	0.40	2.61	0.00	0.00	53.03	872.24	1254.22
	CV	0.03	0.01	0.04	0.00	0.02	0.00	0.02	0.00	0.11	0.01	0.00	0.00	0.00	0.00	0.00
	Dest	0.02	1.94	0.01	3.60	0.02	0.00	0.02	0.00	0.04	0.02	0.00	0.00	0.10	2.34	2.46
Point 2	Average	0.48	207.38	0.04	1485.71	0.75	0.00	0.76	0.01	0.25	1.89	0.00	0.01	46.00	596.41	855.49
	Minimum	0.48	206.56	0.04	1462.35	0.74	0.00	0.75	0.01	0.24	1.89	0.00	0.01	45,00	596.25	854.65
	Maximum	0.49	208.34	0.05	1498.12	0.76	0.00	0.77	0.01	0.25	1.89	0.00	0.01	47,00	596.65	857.08
	CV	0.01	0.00	0.13	0.01	0.01	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.02	0.00	0.00
	Dest	0.01	0.90	0.01	20,24	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	1.00	0.21	1.38

Conciencia Digital
ISSN: 2600-5859
Vol. 7 No. 3.2, pp. 18 – 33, September 2024
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Table 3

Water quality parameters at different sampling points (continued)

Parameter / Sampling point 3	Statistical	Copper	Total hardness	Aluminum	Chlorides	Nickel	Lead	Zinc	Silver	Cyanide	Barium	Bromine	Molybdenum	Dissolved oxygen	BOD5	COD
Sampling point 3	Average	0.38	138.34	0.04	787.07	0.56	0.00	0.60	0.00	0.08	1.41	0.00	0.01	33.09	381.16	103.42
	Minimum	0.36	137.56	0.03	786.23	0.56	0.00	0.59	0.00	0.08	1.41	0.00	0.01	32.58	380.21	103.18
	Maximum	0.39	139.22	0.04	787.56	0.57	0.00	0.60	0.00	0.09	1.41	0.00	0.01	33.44	381.82	103.87
	CV	0.04	0.01	0.16	0.00	0.01	0.00	0.01	0.00	0.07	0.00	0.00	0.00	0.01	0.00	0.00
	Dest	0.02	0.83	0.01	0.73	0.01	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.45	0.85	0.39
Point 4	Average	0.23	121.20	0.03	497.17	0.36	0.00	0.38	0.00	0.04	0.88	0.00	0.01	21,11	130.38	63.39
	Minimum	0.23	120.98	0.03	497.12	0.35	0.00	0.37	0.00	0.04	0.88	0.00	0.01	21,10	130.21	63.18
	Maximum	0.24	121.41	0.03	497.22	0.36	0.00	0.38	0.00	0.05	0.89	0.00	0.01	21,12	130.52	63.73
	CV	0.02	0.00	0.00	0.00	0.02	0.00	0.02	0.00	0.13	0.01	0.00	0.00	0.00	0.00	0.00
	Dest	0.01	0.22	0.00	0.05	0.01	0.00	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.16	0.30
Point 5	Average	0.07	90.21	0.01	181.27	0.14	0.00	0.17	0.00	0.00	0.36	0.00	0.01	10.26	92.21	34.64
	Minimum	0.07	89.97	0.01	180.40	0.13	0.00	0.17	0.00	0.00	0.36	0.00	0.01	10,20	92.03	34.50
	Maximum	0.08	90.67	0.01	182.01	0.14	0.00	0.18	0.00	0.00	0.37	0.00	0.01	10.32	92.47	34.82
	CV	0.08	0.00	0.00	0.00	0.04	0.00	0.03	0.00	0.00	0.02	0.00	0.00	0.01	0.00	0.00
	Dest	0.01	0.40	0.00	0.81	0.01	0.00	0.01	0.00	0.00	0.01	0.00	0.00	0.06	0.23	0.16
Point 6	Average	0.06	63.28	0.01	126.79	0.11	0.00	0.12	0.00	0.00	0.28	0.00	0.01	7.22	64.46	24,32
	Minimum	0.06	63.15	0.01	126.55	0.10	0.00	0.11	0.00	0.00	0.26	0.00	0.01	7.21	64.42	24,26
	Maximum	0.06	63.47	0.01	126.99	0.11	0.00	0.12	0.00	0.00	0.29	0.00	0.01	7.22	64.50	24.38
	CV	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00
	Dest	0.00	0.17	0.00	0.22	0.01	0.00	0.01	0.00	0.00	0.02	0.00	0.00	0.01	0.04	0.06

Figure 2 shows the results of the analyses of the main parameters taken into account for the calculation of water quality. Regarding pH, a decreasing trend is observed over time, indicating that the water becomes slightly more acidic. However, pH values remain within an acceptable range close to 7 (neutral). There is an increasing trend in dissolved solids in the water. This suggests an increase in the amount of dissolved particles, which could indicate a deterioration in water quality. Electrical conductivity shows an increasing pattern similar to that of dissolved solids. Higher levels of conductivity are related to a greater presence of dissolved ions in the water. The 5-day Biochemical Oxygen Demand shows fluctuating values, with occasional peaks. High levels of BOD5 suggest a greater amount of organic matter that consumes oxygen during its decomposition.

There is a general upward trend in total water hardness, indicating an increase in the concentration of dissolved minerals, mainly calcium and magnesium. Dissolved oxygen levels show variability, with values generally above 6 mg/L. It is important to highlight the need to maintain adequate oxygen levels for the presence of life in water bodies. Phosphate concentrations appear to remain relatively stable, with occasional peaks. Excessive phosphate levels can contribute to eutrophication.

Fluctuations in ammonia nitrogen levels are observed, with generally low values. Ammonia can be toxic to aquatic life at high concentrations. Chloride concentrations show a slightly increasing trend. High chloride levels may indicate the influence of wastewater or salt intrusion. Turbidity shows variable values, with some peaks. High turbidity reduces water clarity and may affect light penetration and photosynthetic activity. Colour data show considerable variability. Changes in colour may be related to the presence of dissolved or suspended substances.

Table 4

Correlation analysis between parameters

	Color	Turb	pH	Drive	STD	NT	Phosph.	(NH3-N)	Sulf.	DT	Clour.	OD	BOD5
Color													
Turb	0.994												
pH	0.861	0.886											
Drive	0.953	0.965	0.972										
STD	0.980	0.971	0.869	0.958									
NT	0.998	0.993	0.873	0.960	0.986								
Phosph.	0.961	0.973	0.966	0.995	0.947	0.964							
(NH3-N)	0.923	0.947	0.976	0.989	0.930	0.938	0.981						
Sulf.	0.987	0.990	0.899	0.975	0.983	0.985	0.974	0.946					
DT	0.968	0.967	0.925	0.983	0.990	0.979	0.970	0.968	0.977				
Chlorine.	0.977	0.982	0.940	0.986	0.954	0.976	0.996	0.962	0.982	0.967			
OD	0.998	0.995	0.889	0.967	0.977	0.996	0.976	0.939	0.990	0.972	0.989		
BOD5	0.965	0.980	0.911	0.970	0.965	0.978	0.966	0.977	0.966	0.979	0.960	0.969	
COD	0.876	0.898	0.973	0.968	0.906	0.900	0.949	0.988	0.902	0.956	0.922	0.894	0.953

Table 4 indicates the interrelations between various parameters related to water quality. The results reveal the presence of multiple very strong positive correlations (coefficients >0.95) between certain indicators, suggesting a close link and possible dependence between them. First, an exceptionally high correlation is observed between water colour (0.994) and turbidity, total nitrogen (0.998), dissolved oxygen (0.998) and biochemical oxygen demand (0.965). This indicates that these parameters are closely related and could be responding in a similar way to environmental conditions or factors affecting water quality. Similarly, strong correlations were identified between turbidity and electrical conductivity (0.965), total dissolved solids (0.971), nutrients such as phosphates (0.973) and ammonium (0.947), as well as certain ions such as sulphates (0.990) and chlorides (0.982). These close relationships (>0.95) suggest that these parameters could be influenced by common processes and factors. On the other hand, chemical oxygen demand showed more moderate correlations (0.90-0.95) with pH (0.973), ammonium (0.988) and certain ions, indicating a less direct relationship with these parameters compared to the previous ones. This could be due to the influence of other factors that affect chemical oxygen demand in a more complex or independent way.

Table 5

Water quality parameters and their importance

Parameters	Importance	Yo	I*W
pH	1.00	58.20	58.20
Dissolved solids	0.50	94.10	47,00
Electrical conductivity	2.00	35.70	71.30
Dissolved oxygen	5.00	13.20	65.80
Biochemical oxygen demand	5.00	1.30	6.30
Total hardness	1.00	32.30	32.30
Chlorides	0.50	1.20	0.60
Ammoniacal nitrogen	2.00	17.80	35.60
Total phosphates	2.00	21.70	43.40
Color	1.00	15.40	15.40
Turbidity	0.50	32.80	16.40
Total weight	20.5		392.3

Table 6

Sampling points and water quality values

Criterion	Range
Not contaminated	85 - 100
Acceptable	70 - 84
Little polluted	50 - 69
Contaminated	30 - 49
Highly polluted	0 - 29

Table 7

Sampling points water quality values

Sampling Pts.	Worth	Criterion
P1	19,14	Highly polluted
P2	20.54	Contaminated
P3	27.03	Contaminated
P4	33.77	Contaminated
P5	45.23	Contaminated
P6	56.11	Little polluted

Tables 5, 6 and 7 indicate the parameters and their importance for calculating the Water Quality Index. The table indicates the quality criteria and values, and the table gives the results at each sampling point. In summary, the tables provide a framework for assessing and classifying water quality based on its level of contamination. The numerical ranges allow the status of different water bodies or samples to be quantified and compared. The higher the value, the better the water quality, while lower values indicate greater contamination and the need for remedial actions. This suggests that there is a gradual improvement in water quality as one progresses through the sampling points, although pollution levels remain worrying at most points, especially at the first points where pollution is more severe, which maintains a constant level of water pollution, which can directly or indirectly affect the existing biota in the freshwater body, the population of fish that live along the river, and the existence of fishing activity increases the risk of indirectly ingesting a pollutant by humans.

Figure 3

Evolution of water quality in relation to sampling points

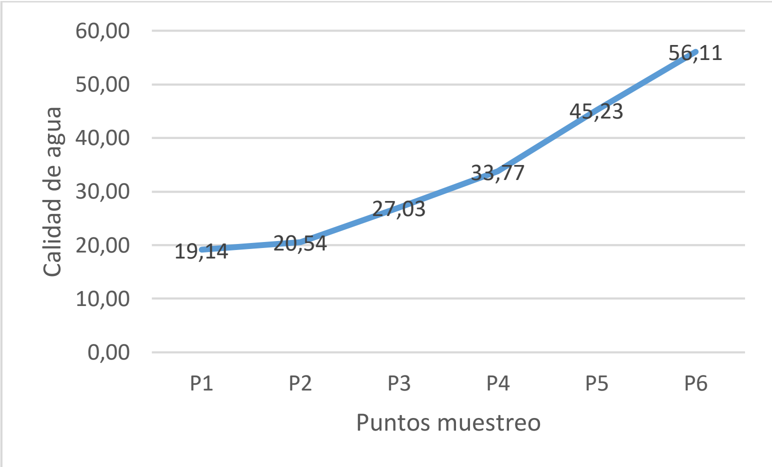

Figure 3 shows the evolution of water quality by sampling point. It starts at point 1, which is where the leachate is formed. As it moves to different distances, the contamination decreases. It is important to highlight that at point 6, despite the distance from the point of origin, the water quality does not reach acceptable values, the contamination persists, in addition to this, points are identified where there are discharges of other contaminants called wastewater, this maintains or increases the contamination values. There is no evidence of controls in the course of the river until reaching the point where it receives another strong load of contaminants, which corresponds to the El Tejar Parish, located 6 km away and the Chimbo Canton, located 10 km away.

Conclusions

- The composition of the leachate generated in the Curgua landfill varies depending on the nature of the waste, in which the majority is made up of organic matter and its degree of decomposition, and the rest is a mixture of other materials such as plastic, glass, metal, the age of the landfill, the design and operation of the landfill, and the climatic conditions. Rain influences the amount of leachate produced, where the pH of the leachate, slightly alkaline, suggests that it is in a constant advanced stage of decomposition, which causes the transformation of organic acids into methane and carbon dioxide, a process known as methanogenesis. It is

ISSN: 2600-5859
Vol. 7 No. 3.2, pp. 18 – 33, September 2024

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worth noting that as the distance increases, a partial decrease in the values of the parameters is evident, however, they remain, which causes the constant presence of contamination in the body of fresh water. This aspect increases the risk of maintaining and potentially increasing contamination in times when it can directly influence the generation of solid waste.

Conflict of interest

Authors must declare whether or not there is a conflict of interest in relation to the submitted article.

Bibliographic References

Abbasi, T., & Abbasi, S.A. (2012). Water quality indices. Elsevier Science. https://shop.elsevier.com/books/water-quality-indices/abbasi/978-0-444-54304-2

Becerra-Moreno, D., Rubio-Gómez, Y., Ramírez-Ríos, L.F., Barajas-Solano, A.F., & Machuca-Martínez, F. (2021). Advanced ozone-based oxidation processes as an alternative treatment for landfill leachates. Science in Development, 12(2), 95-108.https://doi.org/10.19053/01217488.v12.n2.2021.12503

Boyacioglu, H. (2007). Development of a water quality index based on a European classification scheme. Water SA, 33(1), 101-106. https://www.ajol.info/index.php/wsa/article/view/47882/0

Cando, C., & Argüello, J. (2021, December). Methodological document of the economic environmental information statistics in GADM. Solid waste management 2020. INEC. https://www.ecuadorencifras.gob.ec/documentos/web-inec/Encuestas_Ambientales/Municipios_2020/Residuos_solidos_2020/Metodologia_2020_GIRS.pdf

Cardenas-Ferrer, Teresa Margarita, Santos-Herrero, Ronaldo Francisco, Contreras-Moya, Ana Margarita, Rosa-Dominguez, Elena, & Dominguez-Nuñez, Jorge. (2019). Methodological proposal for the urban solid waste management system in Villa Clara. Chemical Technology, 39(2), 471-488. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2224-61852019000200471&lng=es&tlng=es.

Cárdenas-Ferrer, Teresa Margarita, Santos-Herrero, Ronaldo Francisco, Contreras-Moya, Ana Margarita, Rosa-Domínguez, Elena, & Correa -Cortés, Yania. (2020). Design of a plant for the treatment of leachate in the Sagua La Grande landfill. Chemical Technology, 40(2), 413-427.

http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S2224-61852020000200413&lng=es&tlng=es.

Cuichán Ango, JI (2022). Treatment of leachates from the "Romerillos" landfill in the Mejía Canton, Pichincha province, by coagulation - flocculation with ferric chloride [Undergraduate thesis, National Polytechnic School, Quito, Ecuador]. https://bibdigital.epn.edu.ec/bitstream/15000/23015/3/CD%2012434.pdf

Espinosa Noboa, JA (2023). Comprehensive waste management: local public policy as a guarantee of environmental rights, case study of the city of Loja [Master's thesis, Latin American Faculty of Social Sciences (FLACSO), Quito, Ecuador] https://repositorio.flacsoandes.edu.ec/bitstream/10469/19315/2/TFLACSO-2023JAEN.pdf

Espinoza-Quispe, CE, Marrero-Saucedo, FM, & Hinojosa-Benavides, RA (2020). Solid waste management in the municipal administration of Huancavelica, Peru. Letras Verdes. Latin American Journal of Socio-Environmental Studies, 28, 163-177. https://repositorio.flacsoandes.edu.ec/handle/10469/17068

Fernández-Cortés, Yessica, Sotto-Rodríguez, Karla Daniela, & Vargas-Marín, Luis Alberto. (2020). Environmental impacts of coffee production and the sustainable use of the waste generated. Production + Cleaner, 15(1), 93-110.https://doi.org/10.22507/pml.v15n1a7

Gila Hoyas, A. (2022, April 09). The urban solid waste management market in Ecuador. Edited by ICEX Spain Export and Investment, EPE https://www.icex.es/content/dam/es/icex/oficinas/096/documentos/2022/07/documentos-anexos/DOC2022910503.pdf

Huang, Z., Gu, Z., Wang, Y., & Zhang, A. (2019). Improved oxidation of refractory organics in concentrated leachate by a Fe2+-enhanced O3/H2O2 process. Environmental science and pollution research international, 26(35), 35797–35806. https://doi.org/10.1007/s11356-019-06592-y

Lascano Garcés, J.E. (2020). Purification of leachate from the landfill of the city of Puyo, belonging to the Pastaza canton, Pastaza province, using alternative methods "Residual Biomass" [Undergraduate thesis, Amazon State University, Puyo, Ecuador]. https://repositorio.uea.edu.ec/bitstream/123456789/834/1/T.AMB.B.UEA.%20%203273.pdf

León Chimbolema, JG, & Andrade Borja, BF (2021). Complementary biological treatment for leachates as an alternative to mitigate environmental pollution.

Case: "Curgua" landfill. Knowledge Pole, 6(6) https://polodelconocimiento.com/ojs/index.php/es/article/view/2807

Luo, H., Zeng, Y., Cheng, Y., He, D., & Pan, X. (2020). Recent advances in municipal landfill leachate: A review focusing on its characteristics, treatment, and toxicity assessment. The Science of the total environment, 703, 135468. https://doi.org/10.1016/j.scitotenv.2019.135468

Morales Corozo, JP (2021). Hydrological analysis of the leachate generated in the Gonzalo Pizarro Canton landfill, Ecuador. Revista Ciencia UNEMI, 15(38), 24-33. https://dialnet.unirioja.es/descarga/articulo/8377306.pdf

United Nations [UN]. (2019, January 02). Plastics recycling sector is ready for a new boost. https://www.unep.org/en/news-and-reports/reports/plastics-recycling-sector-is-ready-for-a-new-boost

Pellón Arrechea, A., López Torres, M., Espinosa Lloréns, M del C., Escobedo Acosta, R. (2009). Technology for the treatment of leachates from urban solid waste landfills. Chemical Technology, 29, 113-121. https://www.redalyc.org/pdf/4455/445543761014.pdf

Poblete, R., Oller, M., Maldonado, & Cortes, E. (2019). Improved landfill leachate quality using ozone, UV solar radiation, hydrogen peroxide, persulfate and adsorption processes. Journal of Environmental Management, 232, 45-51. https://www.sciencedirect.com/science/article/abs/pii/S0301479718312957

Podlasek, A. (2023). Modeling leachate generation: practical scenarios for municipal solid waste landfills in Poland. Environmental Science and Pollution Research, 30, 13256–13269. https://doi.org/10.1007/s11356-022-23092-8

Pozo Bejerano, J., García Gutiérrez, J. A., & Vázquez Pérez, Y. (2020). Estimation of the average flow rate of leachate generated in the Viñales landfill, Pinar del Río. CIGET-Holguín IDICT (Institute of Scientific and Technological Information), 22(3). https://www.redalyc.org/journal/6378/637869117002/html/

Raza-Carrillo, D., & Acosta, J. (2022). Environmental planning and recycling of urban solid waste. Economy, Society and Territory, 22(69), 519–544. https://doi.org/10.22136/est20221696

Rodríguez Díaz, Y. (2023). Design of an action plan to minimize the environmental risks caused by the municipal landfill in the canton of La Libertad, Santa Elena [Undergraduate thesis, Peninsula de Santa Elena State University, La Libertad, Ecuador]. https://repositorio.upse.edu.ec/bitstream/46000/9180/1/UPSE-TII-2023-0007.pdf

Conciencia Digital

ISSN: 2600-5859
Vol. 7 No. 3.2, pp. 18 – 33, September 2024

www.concienciadigital.org

Tambo López, C.S. (2015, December 9). Proposal for a water quality index as a management tool for the capital's wetlands [Undergraduate thesis, Universidad Santo Tomás, Bogota, Ecuador]. https://repository.usta.edu.co/bitstream/handle/11634/2582/2015cristiantambo.pdf?sequence=8&isAllowed=y

Vaca Rueda, GM (2020). Analysis of the integrated management of solid waste in the Latacunga canton, main actors, 2014-2018 [Specialization thesis, Latin American Faculty of Social Sciences (FLACSO), Ecuador] https://repositorio.flacsoandes.edu.ec/bitstream/10469/16571/2/TFLACSO-2020GMVR.pdf

Vidarte Rodríguez, A., & Colmenares López, MG (2020). Zero waste. Urban solid waste management in Mexico. RICSH Ibero-American Journal of Social and Human Sciences, 9(18), 130 - 150. https://doi.org/10.23913/ricsh.v9i18.217

ISSN: 2600-5859
Vol. 7 No. 3.2, pp. 18 – 33, September 2024

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