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REVIEW ARTICLE

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PHYSICOCHEMICAL EVALUATION OF IRRIGATION WATER AND DETERMINATION OF HEAVY METALS IN BAIXA DE HULENE-B, MAPUTO: IMPACTS ON PUBLIC HEALTH

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ABSTRACT

To assess the effects of heavy metals (lead, mercury, and silver) present in the irrigation water from Baixa de Hulene-B, this study examined both physicochemical and additional chemical parameters in the water. The water floods the aquifers and vegetable cultivation areas during rainfall, carrying waste and solid refuse from the region's cities. This contamination affects the quality of the water used for irrigation, leading to health problems. The research was descriptive and explanatory in nature and employed a quantitative approach using deductive and comparative methods. Systematic water samples were collected from four supply wells. The results indicated that the physicochemical characteristics of the irrigation water did not meet recommended standards. Only three parameters (chloride ions, pH, and hardness) were within acceptable limits, while eight parameters (electrical conductivity, turbidity, total dissolved solids, chemical oxygen demand, nitrates, lead, mercury, and silver) exceeded recommended limits, posing a risk to public health. To safeguard public health, measures should be taken to improve the quality of irrigation water in Baixa de Hulene-B. This includes installing water treatment systems and educating farmers about the risks associated with using contaminated water.

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INTRODUCTION

The Baixa de Hulene-B neighborhood in Maputo is a concern due to its proximity to the country's largest landfill (Vilanculo&Manjate, 2022). The impact of the Hulene landfill on public health extends to the quality of irrigation water used in local agriculture. This area is one of the most disadvantaged in Maputo, facing serious infrastructure problems, such as the absence of sewer systems and adequate roads. This reality facilitates the improper disposal of organic and inorganic waste, exacerbated during rains by runoff from elevated areas, which pollutes local aquifers and wells. The Hulene-B landfill can be a potential source of heavy metals due to the lack of selective treatment and appropriate waste collection methods. The diversity of waste dumped at the site without adequate control poses a persistent threat to both groundwater and the irrigation water for local crops.

The use of this contaminated water poses serious public health risks, given the potential for food contamination and prolonged environmental effects. Contamination of irrigation water is concerning since it can directly impact public well-being. When vegetables are grown with contaminated water, there is a higher risk of food contamination, which may result in foodborne diseases. This study aimed to evaluate the physicochemical parameters and the presence of heavy metals such as copper (Cu), mercury (Hg), and lead (Pb) in the irrigation water of Baixa de Hulene-B, Maputo. It also sought to understand how these factors could influence the quality of irrigated crops and, consequently, the potential risks to public health. In Baixa de Hulene-B, the wells supplying water for irrigation share the same aquifer and are therefore susceptible to contamination from leachate originating from the Hulene-B landfill. This contamination compromises food safety and poses a risk to public health, especially due to the presence of heavy metals such as Cu, Hg, and Pb. Several studies have been conducted on river contamination by heavy metals in Mozambique, focusing on river systems (Boana Fatima, 2011; Cossa Aires, 2019; Gil et al., 2012; Issufo, 2022; Ngovene, 2020; Raso et al., 2022). However, few studies have addressed groundwater contamination, and no specific research has focused on Baixa de Hulene-B in the context of agriculture, irrigation water quality, and public health. Thus, this study is pioneering in investigating heavy metal contamination of water in the area, providing a relevant knowledge base for future risk assessments conducted by government agencies such as MITADER and ARA-SUL, and promoting the development of sustainable management practices and sanitary interventions. The physicochemical analysis of irrigation water in Baixa de Hulene-B, Maputo can contribute to environmental protection by reducing toxicity caused by heavy metal levels from companies that dump waste directly into the Hulene-B landfill. This dumping results in environmental contamination, affecting the local biota and contaminating water and soil. On the other hand, the physicochemical analysis of irrigation water in Baixa de Hulene-B is essential to preserve life and maximize water use efficiency, thereby increasing the economic yield through agricultural production. This generates income for the country and drives national economic growth. Using well water from Baixa de Hulene-B to irrigate vegetables, after the adoption of appropriate measures, can help reduce the incidence of diseases caused by heavy metals, such as brain damage, cancer, anemia, and kidney problems. Furthermore, this approach can mitigate diseases related to untreated water consumption, such as typhoid fever, paratyphoid fever, cholera, bacillary dysentery, diarrhea, and hepatitis, among other waterborne diseases. Heavy metals such as lead, mercury, cadmium, arsenic, and chromium, which have high density and are toxic, are commonly known as heavy metals. They are prevalent in the environment due to industrial activities, mining, agriculture, and the use of fossil fuels (Asamoah et al., 2021; Khan &Kurny, 2012; Safiur Rahman et al., 2021). Recent studies demonstrate that prolonged exposure to these metals can cause problems in the nervous system, kidneys, heart, and increase the risk of cancer while impairing child development (Gonzaga &Fontgalland, 2023; Marini & de Janeiro, 2009). Heavy metal contamination also affects ecosystems, as these metals accumulate in soil, water, and living organisms, compromising biodiversity, the food chain, and the quality of natural resources (Costa Maria, 2013; Obiri-Yeboah et al., 2021). The development of cleaner technologies, sustainable agricultural practices, industrial wastewater treatment, and appropriate waste management policies are examples of prevention and control measures aimed at reducing exposure and the harmful effects of these metals. Due to the discharge of heavy metals into rivers and seas, mining activities pollute water bodies (Banzewa Mutombo et al., 2022).

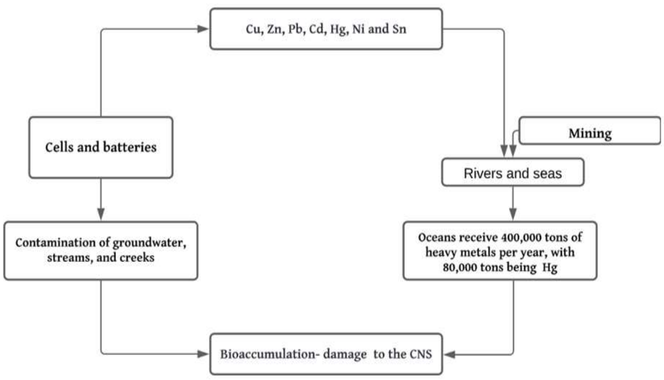

Figure 1: Heavy Metal Contamination Cycle

Metals such as copper (Cu), zinc (Zn), lead (Pb), cadmium (Cd), mercury (Hg), nickel (Ni), arsenic (As), chromium (Cr), cobalt (Co), and tin (Sn) are among those considered harmful. Groundwater and rivers can be contaminated by landfills due to improper disposal of batteries and other waste (Khan & Kurny, 2012). These substances are bioaccumulative and non-biodegradable, meaning they can accumulate in organisms and, when entering the food chain, can cause damage to the human central nervous system (CNS) over the food chain (Gupta, Pathak, & Fulekar, 2014).

Contamination Cycle of Heavy Metals and Risk Activities: Contamination Cycle of Heavy Metals and Risk Activities as shown in Illustration in the Figure 1.This cycle involves human activities that lead to the release, transport, and accumulation of these elements, harming the environment and affecting human health.

MATERIALS AND METHODS

Study area: Hulene-B (Fig.2) is located in Municipal District 4 of Ka Mavota. This district comprises several expanding neighborhoods primarily inhabited by individuals who fled other parts of the country in search of better living conditions, mainly as a result of the civil war. Ka Mavota has a population of 293,766, with 141,301 men and the remainder female. The neighborhoods of Ferroviário, Mahotas, and Hulene-B are the most populous in the district, with a total of 45,000 to 49,000 inhabitants. Additionally, there are other neighborhoods with 20,000 to 29,000 people.

Figure 2. Contamination by solid waste and its impact on the quality of irrigation water in Baixa de Hulene-B, Maputo

Sample Collection: Water samples were collected in dry season. Initially, one-liter plastic bottles and containers were cleaned and disinfected using a 1% sodium hypochlorite (NaClO) solutionbefore being filled with water from the location to be analyzed. To facilitate homogenization before analysis, an air space was left in the bottles. The samples were sent to the laboratory on the same day, in a 20-liter cooler with ice packs. Collection was carried out in the morning, between five and six hours, at four wells, and the samples were coded using points 1 to 4 (Fig.4). The codes were assigned based on the distance between the sample collection point and the Hulene dump; point 1 is the well closest to the dump, and point 4 is the well farthest from the dump.The systematic selection of farmers and consumers for interviews was based on their availability and willingness. Research participants were individuals of both sexes aged between 18 and 65 years.

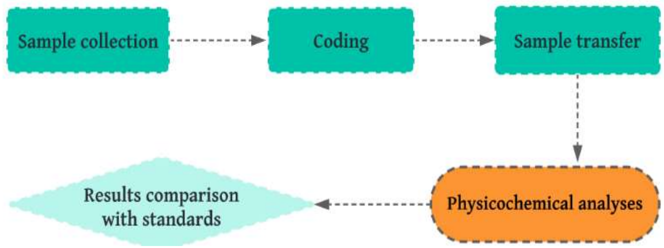

Fig. 4. Flowchart of Irrigation Water Quality Assessment

Fig. 5 shows 5 shows the methods and analytical techniques used in determining the water parameters.

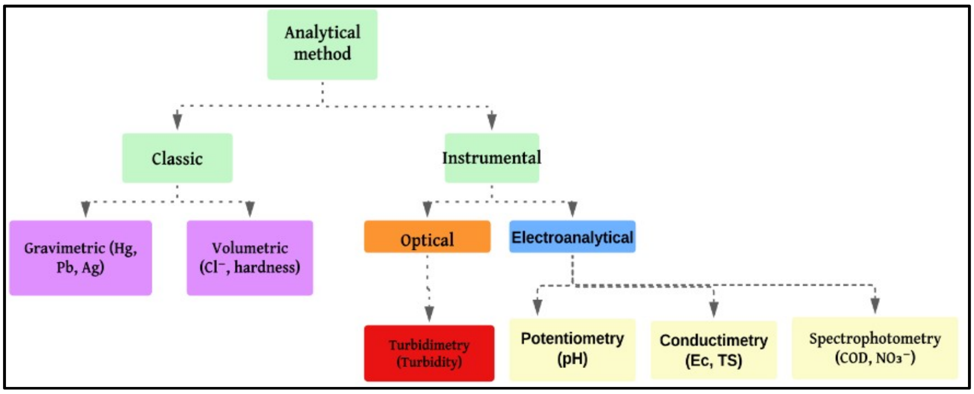

Figure 5. Methods Used in the Experimental Section

Fig. 6. Different shades in the color of the water in the Hulene-B lowlands

Table 1. Average results of the physicochemical parameters of water used for irrigating vegetable

Collection Point	Temp.(ºC)	pH	Cond (mS/ cm^{-1})	Turb (NTU)	Hardness (mg/L)	Cl^- (ppm)	TS (mg/L)	COD (ppm)	NO_3^-(71,14mg/L)
1	21.3	8.19	4.84	60	37	132.54	550	-	-
2	20.6	7.71	4.83	55	22	114.21	455	-	-
3	20.4	7.41	4,82	10	31,4	146.64	300	-	-
4	18.7	7.12	4,79	4	30,12	131.13	220	-	-
Average Value		7.6	4.82	126	30,13	131.13	1355	2913.7	71.14

RESULTSAND DISCUSSION

Results of Direct Observation: The results of direct observation showed that at each of the four sampling points, the water used for irrigating vegetables in the Hulene-B lowlands exhibited varying color tones (Fig. 6). Additionally, it was observed oil stains suspended in the water and urban solid waste. These results indicate that the water used for irrigation contains impurities and contaminants, which may affect the quality and safety of the vegetables grown in the Hulene-B lowlands. Table 1 shows the results of physicochemical parameters of water used for irrigating vegetables in the study area. The results show that the evaluated water is basic, with an average pH of 7.6. This value is within the recommended range by FAO standards, which is 6.5 to 8.4, and also complies with the Environmental Quality Standards Regulation No. 58 and Effluent Emission Regulations, which establish the normal pH range for irrigation water as 6.5 to 8.4. Thus, the water is considered adequate for irrigation.However, the average electrical conductivity was 4.8 mS/cm. According to **FAO Decree No.** 18/2004, water with an electrical conductivity of4.01 to 6.00 mS/cm is considered extremely saline and undesirable for irrigation. This value indicates that the water is not suitable for irrigating vegetables. The obtained value was twice as high as the value found by Cossa (2019), which was 1.57161 mS/cm. This discrepancy suggests that the water contains high levels of salt. The turbidity averaged 120 NTU, exceeding the limit permitted by CONAMA Resolution No. 357/2005 for vegetable irrigation water. Although turbidity itself does not harm plants, turbidity particles have the potential to carry absorbed organic matter, which can cause unpleasant odor and taste in the cultivated products. On the other hand, the average hardness of the water is 31.12 mg/L, which corresponds to the recommended standards by Funasa (2014),which establish a restriction range of 0 to 75 mg/L for irrigation water. Regarding chloride ions, the found value was 131.1 mg/L, which is close to the 140 mg/L value obtained by Chimbatão (2012) when assessing the quality of irrigation water in the Infulene valley. However, Boane& Ayres (2011) state that chloride ion levels around 250 mg/L are above the maximum recommended limit for irrigation water. The obtained value for chemical oxygen demand (COD) was 2913.7 ppm. According to CONAMA Resolution No. 20, COD for irrigation water should not exceed 90 mg/L. Therefore, the obtained value is far above the recommended irrigation limit.

This indicates that the water contains organic substances and pollutants, making it unsuitable for irrigation. The concentrations of mercury, silver, and lead in the Hulene-B lowlands irrigation water were determined using the gravimetric method, also known as the analytical march. However, the limitations of this method prevented the quantification of ion concentrations of these metals. Colorimetry was used to overcome this limitation. This method uses the color of the salt formed when a specific reagent is added to measure metal concentration. The irrigation water from Hulene-B lowlands exhibited high concentrations of lead and low concentrations of mercury and silver. The presence of mercury, silver, and lead in the irrigation water of Hulene-B lowlands raises concerns about prolonged exposure to farmers, bioaccumulative effects, and public health. Prolonged exposure to mercury can cause health problems, even at low concentrations. This metal is known to be toxic and can cause neurological damage and developmental issues in children (Gonçalves et al., 2016; Gonzaga &Fontgalland, 2023). Additionally, due to its high toxicity, organomercurial compounds, in which mercury is bonded to carbon atoms, are particularly dangerous. Exposure to these materials can harm the organs and systems of the human body. Although silver concentrations are low in the irrigation water, silver can also be harmful to the environment and human health. Health issues such as damage to the nervous system, kidneys, and liver may result from prolonged exposure to high concentrations of silver. Silver can also accumulate in the body over time, increasing health risks. The irrigation water from Hulene-B lowlands contained high concentrations of lead, a toxic metal. Prolonged exposure to lead can impair the nervous system, affect cognitive development in children, and cause renal and cardiovascular problems. Lead can also accumulate in the human body over time, increasing health risks. Therefore, farmers working directly with contaminated water are at significant risk due to the presence of these metals in the irrigation water. Prolonged exposure to this toxic metal can lead to severe health problems.

CONCLUSION

The water from the Hulene-B lowlands has concerning physicochemical characteristics. The pH is 7.6, indicating moderate alkalinity. The electrical conductivity of 4.82 mS/cm shows that dissolved substances are present in the water. The water has a turbidity of 126 NTU, indicating it is quite turbid. The hardness of 30.13 mg/L suggests that the water contains minerals. The chloride ion concentration is 131.13 mg/L, and the total dissolved solids concentration is 1355 mg/L. The chemical oxygen demand (COD) of 2913.7 mg/L indicates that there are organic substances in the water. The nitrate concentration is 71.14 mg/L. The water also contains lead, silver, and mercury ions, as demonstrated by the color change of the indicators. The irrigation water in Hulene-B lowlands has low concentrations of mercury and silver but high concentrations of lead. The presence of these heavy metals in the water can affect the quality of the vegetables grown in the region. Additionally, consumers may develop health issues after consuming these contaminated foods. It is necessary to take measures to improve the quality of the irrigation water and protect the food produced in the Hulene-B lowlands**.**

REFERENCES

Gupta, S., Pathak, B. & Fulekar, M. H. 2014. Molecular approaches for biodegradation of polycyclic aromatic hydrocarbons: A review. *Review of Environmental Science and Biotechnology, 14*(3), 241-269. https://doi.org/10.1007/s11157-014-9353-3

Asamoah, B. D., Asare, A., Okpati, S. W., & Aidoo, P. (2021). Heavy metal levels and their ecological risks in surface soils at Sunyani magazine in the Bono region of Ghana. *Scientific African*, 13. https://doi.org/10.1016/j.sciaf.2021.e00937

Banzewa Mutombo, A., Atibu, E. K., Mbuya wa Mutombo, J., Kalonda, E. M., Bakatula, E. N., Kanda, V. N., Koy, R. K., Mulaji, C. K., Carvalho, F. P., & Poté, J. (2022). Contamination by heavy metals from mining activities: An ecological impact assessment of Mura and Kimpulande Rivers, Democratic Republic of the Congo. *Watershed Ecology and the Environment*, 4, 148–157. https://doi.org/10.1016/j.wsee.2022.10.004

Beyene, M. T., Leibowitz, S. G., Dunn, C. J., &Bladon, K. D. (2023). To burn or not to burn: An empirical assessment of the impacts of wildfires and prescribed fires on trace element concentrations in Western US streams. *Science of the Total Environment*, 863. https://doi.org/10.1016/j.scitotenv.2022.160731

Carvalho, F. P. (2017). Mining industry and sustainable development: Time for change. *Food and Energy Security*, 6(2), 61–77. Wiley-Blackwell Publishing Ltd. https://doi.org/10.1002/fes3.109

Gonzaga, H. F., &Fontgalland, I. L. (2023). Neurological diseases caused by metal contamination in Brazil's waters. *Journal Archives of Health*, 4(3), 909–928. https://doi.org/10.46919/archv4n3-017

Costa, Maria. (2013). Microcontaminantes ambientais, um estudo aplicado da sua importância médico-legal.

Defarge, N., Spiroux de Vendômois, J., & Séralini, G. E. (2018). Toxicity of formulants and heavy metals in glyphosate-based herbicides and other pesticides. *Toxicology Reports*, 5, 156–163. https://doi.org/10.1016/j.toxrep.2017.12.025

FAO-Organização das Nações Unidas para Alimentação Agricultura. 2004. Disponível em https://faolex.fao.org/ docs/pdf/moz65555.pdf

Gonçalves, R. M., Gonçalves, J. R., & Gerais, A. (2016). Heavy Metals and Their Presence in Human Milk.

Khan, M. H., &Kurny, A. S. W. (2012). Characterization of Spent Household Zinc-Carbon Dry Cell Batteries in the Process of Recovery of Value Metals. *Journal of Minerals & Materials Characterization & Engineering*, 11(6).

Kirschke, S., Avellán, T., Bärlund, I., Bogardi, J. J., Carvalho, L., Chapman, D., Dickens, C. W. S., Irvine, K., Lee, S. B., Mehner, T., & Warner, S. (2020). Capacity challenges in water quality monitoring: understanding the role of human development. *Environmental Monitoring and Assessment*, 192(5). https://doi.org/10.1007/s10661-020-8224-3

Marini, C. B., & De Janeiro, R. (2009). Toxicity and bioaccumulation of copper in photoautotrophic microorganisms.

Li, Y., Li, J., Gao, L., & Tian, Y. (2018). Irrigation has more influence than fertilization on leaching water quality and the potential environmental risk in excessively fertilized vegetable soils. *PLoS ONE*, 13(9). https://doi.org/10.1371/journal.pone.0204570

Obiri-Yeboah, A., Nyantakyi, E. K., Mohammed, A. R., Yeboah, S. I. I. K., Domfeh, M. K., & Abokyi, E. (2021). Assessing potential health effects of lead and mercury and the impact of illegal mining activities in the Bonsa river, Tarkwa Nsuaem, Ghana. *Scientific African*, 13. https://doi.org/10.1016/j.sciaf.2021.e00876

RESOLUÇÃO CONAMA N° 357, DE 17 DE MARÇO DE 2005 (RETIFICADA-AO FINAL)*. (2005).Disponivel em https://www.legisweb.com.br/legislacao/?id=102255

SafiurRahman, M., Shafiuddin Ahmed, A. S., Rahman, M. M., Omar FaruqueBabu, S. M., Sultana, S., Sarker, S. I., Awual, R., Rahman, M. M. & Rahman, M. (2021). Temporal assessment of heavy metal concentration and surface water quality representing the public health evaluation from the Meghna River estuary, Bangladesh. *Applied Water Science*, 11(7). https://doi.org/10.1007/s13201-021-01455-9

Sequeira, M. D., Castilho, A. M., Tavares, A. O. & Dinis, P. (2020). Assessment of superficial water quality of small catchment basins affected by Portuguese rural fires of 2017. *EcologicalIndicators*, 111, 105961. https://doi.org/10.1016/j.ecolind.2019.105961

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