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Assessment Of The Physical And Chemical Quality Of Water (Wells And Drillings) Consumed In Some Areas Of Senegal And Proposing A Treatment Method Based On Mangosteen Powder Used As A Biosourced Material

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Abstract
The lack of access to safe drinking water remains a critical issue in many regions of Senegal, particularly in rural areas. This study aims to assess the physicochemical characteristics of groundwater (wells and boreholes) in the areas of Khombole, Thies, Dakar, Bambey, Diourbel, and Kaolack. The parameters measured include pH, electrical conductivity, turbidity, total phosphorus, fluoride, hardness, nitrates, and magnesium.
With the goal of developing a sustainable and accessible water treatment solution, we explored the adsorptive potential of a local bio-based material: mango peel powder. The performance of
this material was evaluated using a multi-parameter analyzer (BET-M500T, Infitek brand) based on the adsorption method.
The results indicate a significant efficiency in the removal of several micropollutants, highlighting the potential of this approach for decentralized treatment of contaminated water.

Keywords: *Mango shell powder, Multi-parameter analyzer, pH, electrical conductivity, turbidity, total phosphorus, fluoride, hardness, nitrates, and magnesium.*

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I. Introduction

Senegal, as a semi-arid and arid country, faces significant challenges related to water availability and access [1, 2]. With irregular rainfall patterns and prolonged dry seasons, the sustainable management of water resources is crucial to meet the growing needs of its population estimated at approximately 18.70 million inhabitants in 2024 and to support key sectors such as agriculture, industry, and public health [3]. The country possesses diverse water resources (both surface and groundwater) that serve to supply the population. Various policies and strategies have been implemented to improve integrated water resource management, strengthen water infrastructure, and promote universal access to safe drinking water and sanitation [4].

Although notable progress has been made in modernizing and improving water distribution systems to ensure access for both urban and rural populations, the quantity and quality of water available to certain segments of the population remain inadequate. The consumption of poor-quality water is observed in both urban and rural areas [5].

In this context, the effective and sustainable management of water in Senegal requires an integrated, inclusive, and participatory approach engaging the government, local communities, private sector stakeholders, civil society, and international partners. It also calls for continued investments in water infrastructure, conservation of aquatic ecosystems, promotion of sustainable agricultural practices, and the strengthening of institutional and technical capacities to address future water management challenges.

In this part of our study, we aim to evaluate the physicochemical quality of water (from wells and boreholes) consumed in areas such as Pikine, Thies, Khombole, Bambey, Diourbel, and Kaolack, before proposing treatment methods based on bio-based materials such as mango seed shell powder.

II. Materials And Methodology

The aim of this study was to assess the presence and concentration of micropollutants in groundwater sources across the regions of Dakar, Thies, Khombole, Bambey, Diourbel, and Kaolack. Water samples were collected from wells located within these areas. For each analysis, 50 mL aliquots were prepared.

An initial blank analysis was conducted to identify the types and levels of micropollutants present. Following this, a bio-based adsorbent mango seed powder was introduced to evaluate its efficacy in contaminant removal.

The treatment procedure was based on adsorption. Specifically, 10 mg of the adsorbent were added to 50 mL of well water, followed by agitation for 15 minutes. The suspension was then allowed to settle for 10 minutes prior to filtration. The filtrate was subsequently analyzed using a multi-parameter analyzer (BET-M500T, Infitek; see Figure 1).

The BET-M500T enables multiparameter measurements applicable in fields such as disease surveillance, environmental monitoring, organic agriculture and forestry, water quality assessment, scientific research, and higher education.

Figure 1 : Multi-parameter analyser, BET-M500T

III. Results And Discussions

Results before treatment

Analysis of the physical and chemical parameters of our water samples reveals the presence of several contaminants at high levels (Table 1).

- For physical parameters, the measured values for electrical conductivity (EC), turbidity and pH show that the water from these wells has a deteriorating physical appearance.
- For chemical parameters, analysis of the results reveals the presence of naturally occurring micropollutants (nitrates, phosphorus, magnesium, calcium and fluoride) at high levels.

Table 1: Values of physical and chemical parameters according to location.

Parameters	pH	Conductivity µs/cm	Turbidity NTU	Phosphorus mg/L	Calcareous mg/L	Nitrate mg/L	Fluoride mg/L	Magnesium mg/L
Normes internationales	6.5 to 8.5	1055	5	0.2	270	50	1.5	50
Khombole	7.8	300	3.2	0.01	250	0.2	0	35
Bambey	8	387	**15**	0.09	380	0.8	0	50
Diourbel	7.9	400	**19**	0.1	325	2.3	0.2	40
Kaolack	8.1	450	**22**	0.1	180	5	**2**	20
Thies	7.5	300	2	0.01	220	0.1	0	35
Dakar	8	350	3	0.1	170	1	0	30

Results after treatment

Application of the mango seed shell powder as a bio-adsorbent demonstrated a high level of efficiency in the removal of micropollutants from groundwater samples. Decontamination rates ranged from 50% to nearly 100%, depending on the type and initial concentration of the contaminants (Table 2). These results highlight the strong adsorption capacity of the biosorbent and its potential for use in decentralized or low-cost water treatment applications.

Table 2: Treatment of water from different sites using mango kernel powder.

Parameters	pH	Conductivity µs/cm	Turbidity NTU	Phosphorus mg/L	Calcareous mg/L	Nitrate mg/L	Fluoride mg/L	Magnesium mg/L
Normes internationales	6.5 to 8.5	1055	5	0.2	270	50	1.5	50
Khombole	7.7	200	1	0	180	0	0	30
Bambey	8	260	3	0	250	0	0	45
Diourbel	7.9	270	4	0	225	0	0	35
Kaolack	8	305	5	0	100	0	0	15
Thies	7.6	190	1	0	270	0	0	30
Dakar	8	300	1	0	100	0	0	25

Discussions

Physical parameters

pH

The acidity or alkalinity of a medium is defined by its pH. According to international standards set by the World Health Organization (WHO), the acceptable pH range for drinking water lies between 6.5 and 8.5. Water with a pH below this range tends to have a bitter taste and may corrode certain materials [6]. Conversely, water with a pH above the recommended range may develop an unpleasant taste and lead to the formation of deposits, giving the impression of water stagnation or sedimentation [7].

Natural variations in the pH of water sources are primarily influenced by the geological characteristics of the soil and the origin of the water supply.

Based on the results obtained from our analysis, followed by treatment using either mango seed shell powder or cassava flour (Figure 2), the water samples from the various sites exhibited pH values that were generally slightly basic. Notably, only the water sample from the Thies site showed an increase in pH (+0.1 units) after treatment with mango seed shell powder [8, 9]. For all other sites, pH values either decreased slightly or remained constant regardless of the adsorbent used.

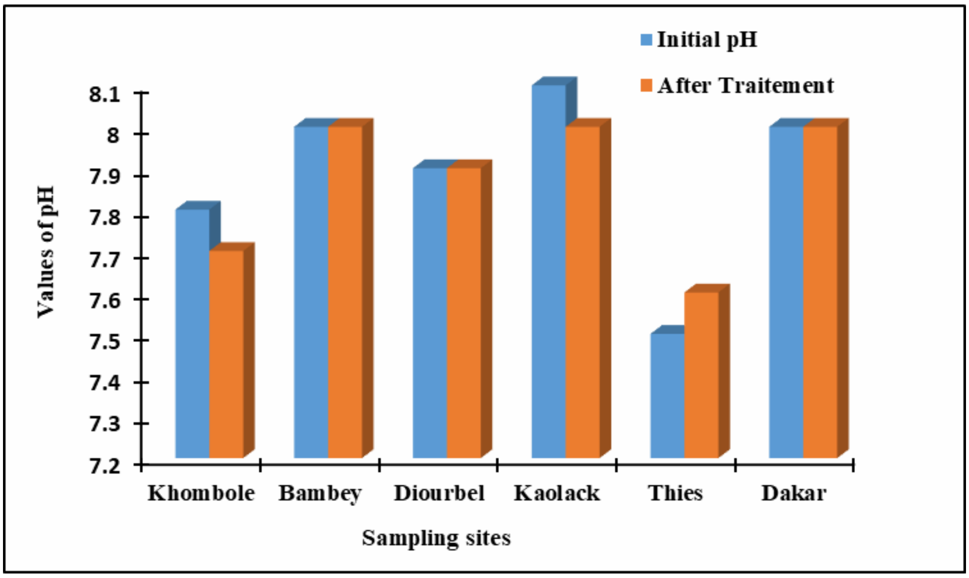

Figure 2: pH evolution of samples from each site before and after treatment with mango shell powder

Electrical Conductivity (EC)

Electrical conductivity provides insight into the degree of mineralization and serves as an important indicator of water composition. It offers a rapid assessment of the nature and concentration of dissolved salts present in the water [10].

The results show a decrease in electrical conductivity compared to the initial values (Figure 3), indicating that a portion of the micropollutants was retained by the adsorbents, thus reducing the overall ionic content of the water [11].

In sites such as Kaolack, Diourbel, and Bambey, the high conductivity levels observed are attributed to the elevated mineral content of the local geological formations.

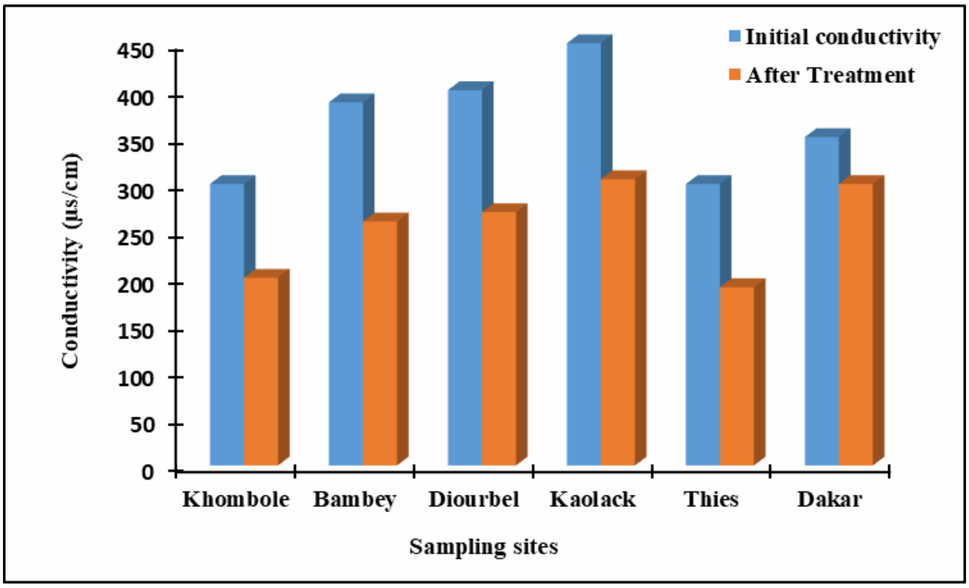

Figure 3: Changes in water conductivity at different sites before and after treatment.

Turbidity

Water turbidity is a measure of the amount of suspended particles that affect water clarity. These particles may include sediments, algae, microorganisms, or other organic and inorganic matter. Turbid water appears cloudy or opaque due to the presence of these suspended particles [12].

High turbidity levels can be indicative of pollution, surface runoff, soil erosion, or other environmental disturbances. Moreover, elevated turbidity can hinder water treatment processes, negatively impact aquatic life, and reduce the aesthetic and sanitary quality of water for human consumption [13].

Based on the analysis of our results, a significant reduction in turbidity was observed across all water samples (Figure 4). These findings demonstrate the effectiveness of the bio-based material used in this study for micropollutant removal, as reflected by the substantial decrease in turbidity [14].

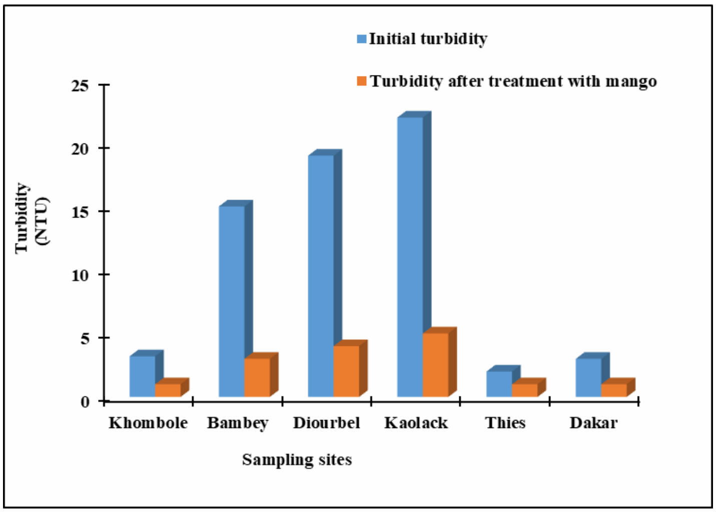

Figure 4: Changes in water turbidity at different sites before and after treatment.

Chemical parameters

Phosphorus

The presence of phosphorus in water is a significant concern in terms of water quality. Phosphorus is widely used in the production of detergents, agricultural fertilizers, industrial processes, and various other applications. When phosphates enter water bodies, they can have multiple environmental and public health impacts [15].

Phosphorus acts as a nutrient that promotes the excessive growth of algae in aquatic environments, a phenomenon known as eutrophication. As these algae die and decompose, they consume dissolved oxygen in the water, potentially leading to fish kills and the decline of other aquatic organisms [16].

Phosphorus can also react with calcium and magnesium ions present in water to form precipitates, resulting in increased turbidity and negatively affecting the taste and odor of the water.

Moreover, the algal blooms triggered by phosphorus disrupt the ecological balance of aquatic ecosystems, reduce biodiversity, and alter the structure and functioning of aquatic communities.

Our analytical results clearly indicate that phosphorus was completely removed from the water samples following treatment with both mango seed shell powder and cassava flour (Figure 5). These findings are consistent with previous studies involving the use of plant-based materials for phosphorus removal from contaminated water sources [17].

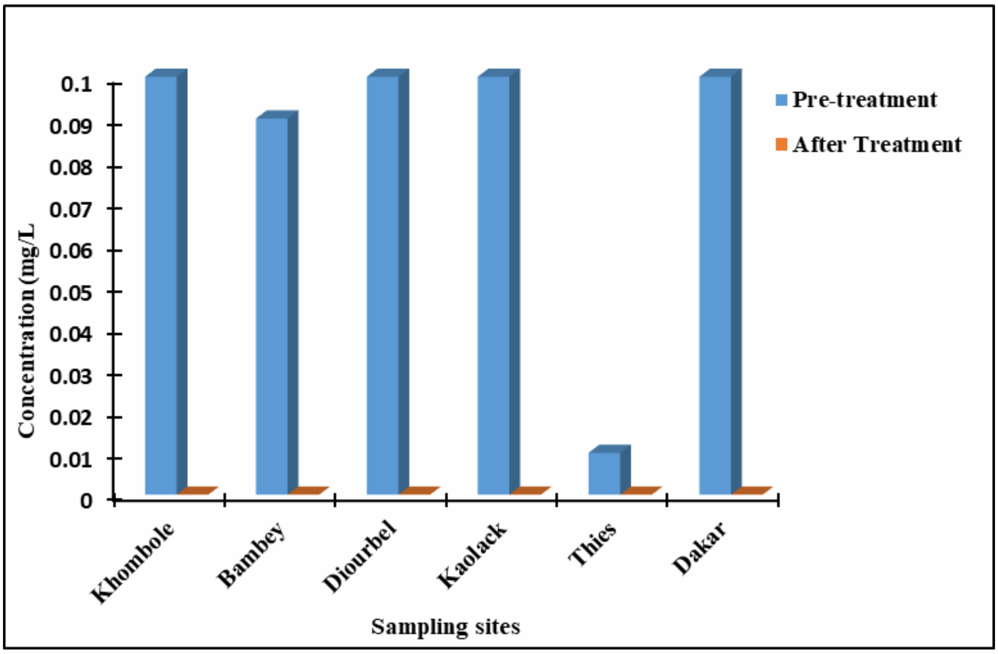

Figure 5: Variation in phosphorus content according to sampling sites.

Limestone

Limescale formation is a widespread issue in many regions of Senegal, primarily due to the high concentrations of calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$) in the water supply. Upon heating or evaporation, these minerals precipitate, leaving behind white or grayish deposits commonly referred to as scale on surfaces. In addition to aesthetic concerns, limescale interacts with soaps and detergents to form insoluble compounds, thereby reducing their cleaning efficiency and leaving residues on skin, hair, and fabrics [18]. Over time, the buildup of limescale can lead to pipe constriction and reduced water flow, resulting in significant plumbing problems and increased maintenance costs.

Various filtration systems are available to reduce the concentration of hardness-causing minerals, and both chemical and natural descaling agents have been investigated for their efficacy. In this study, we evaluated the potential of mango seed shell powder as a low-cost, natural adsorbent for limescale removal from water samples collected in different regions [19].

Our findings indicate that mango seed shell powder exhibits significant adsorptive capacity for calcium and magnesium ions, effectively reducing limescale formation (Figure 6). The performance of this biosorbent is comparable to that of materials reported in previous studies [20], highlighting its potential as an environmentally friendly alternative for water softening applications.

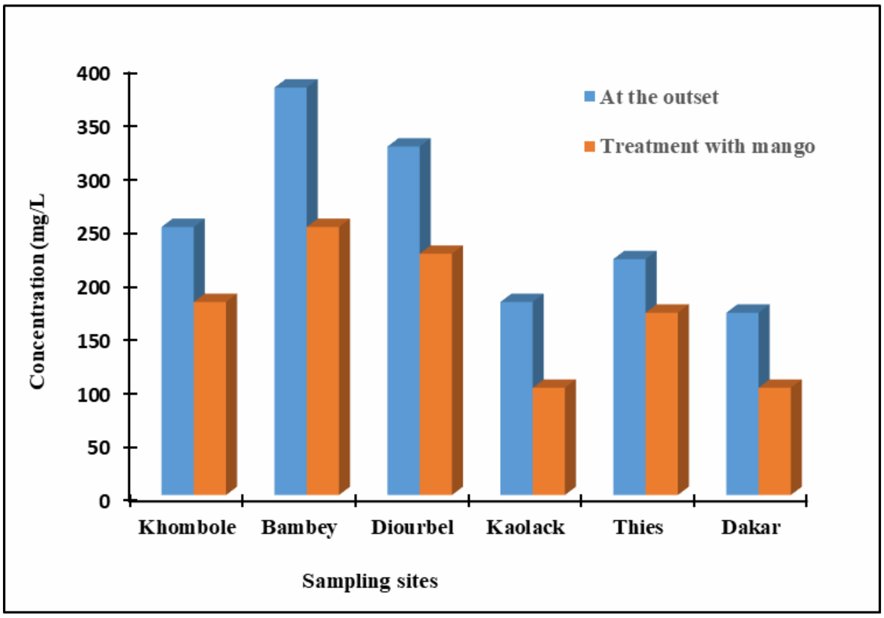

Figure 6: Variation in limestone content according to sampling sites.

Nitrates

The presence of nitrates in water is a major concern due to their potential impacts on both human health and the environment. Nitrates (NO) are chemical compounds composed of nitrogen and oxygen, and they commonly occur in the environment as a result of both natural processes and anthropogenic activities [21].

One of the primary sources of nitrate contamination is the extensive use of nitrogen-based fertilizers in agriculture. Nitrogen from fertilizers can be converted into nitrates, which then leach into surface water and groundwater [22]. Additionally, wastewater discharges from urban and industrial areas can contribute significantly to nitrate pollution [23]. The decomposition of organic matter, such as animal waste and decaying vegetation, also releases nitrogen, which can subsequently be transformed into nitrates.

High concentrations of nitrates in drinking water pose serious health risks, particularly for infants and pregnant women. In the human stomach, nitrates can be converted into nitrites, which may react with amines to form nitrosamines compounds that are potentially carcinogenic. This can lead to methemoglobinemia, or "blue baby syndrome", a condition that impairs the blood's ability to carry oxygen [24].

Moreover, nitrate accumulation in surface waters can stimulate the excessive growth of algae and aquatic plants, leading to eutrophication. This overgrowth disrupts the ecological balance of aquatic ecosystems, reduces biodiversity, and can result in oxygen-depleted "dead zones" [25].

In this study, the application of mango seed shell powder to various water samples resulted in a significant reduction in nitrate concentrations (Figure 7). The performance of this bioadsorbent closely aligns with results obtained using banana peel as a treatment method [26], highlighting its potential as an effective and sustainable solution for nitrate removal from contaminated water.

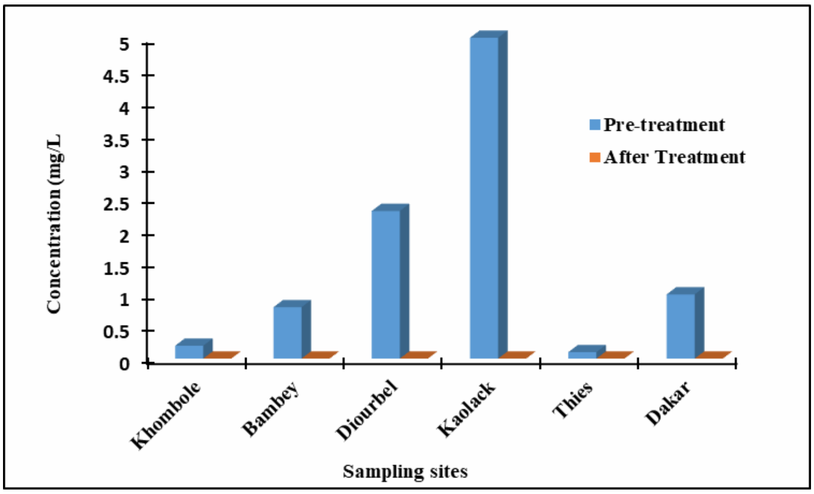

Figure 7: Variation in nitrate content according to sampling sites.

Fluoride

The presence of fluoride in water is an important and sometimes controversial issue. Fluoride is a naturally occurring chemical element found in many soils and rocks [27]. It can also be intentionally added to drinking water to help prevent dental caries a practice known as water fluoridation. When added at optimal levels, fluoride has been shown to effectively reduce the risk of tooth decay without causing significant health problems [28].

However, it is crucial to monitor and regulate fluoride concentrations in water to prevent excessive exposure. Overconsumption of fluoride can lead to dental fluorosis, a condition that affects the appearance of tooth enamel. At very high levels, fluoride exposure can also result in more serious health issues [29].

According to the results from the analysis of our water samples, fluoride was detected at only two sites Diourbel and Kaolack. The bioadsorbents used in this study demonstrated strong efficiency in removing fluoride from the contaminated samples (Figure 8). The use of mango seed shell powder for fluoride removal adds to the growing list of bio-based materials validated by scientific research for water decontamination applications [30].

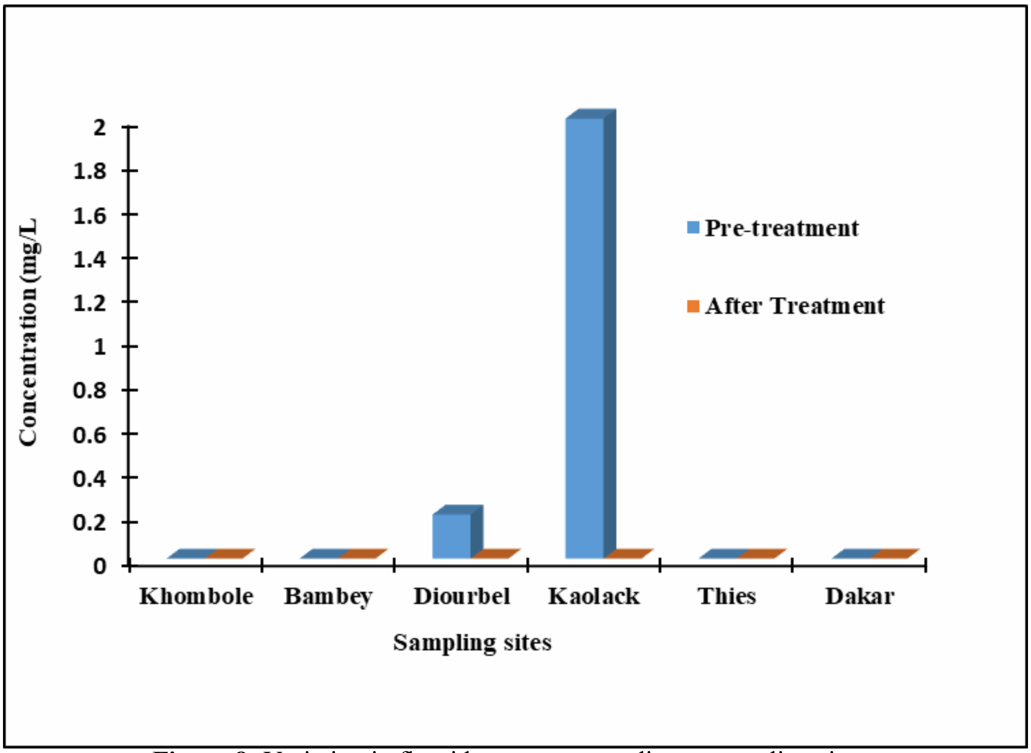

Figure 8: Variation in fluoride content according to sampling sites.

Magnesium

The presence of magnesium in water is also an important aspect when considering drinking water quality and public health. Magnesium is an essential element for the human body, playing a crucial role in numerous biological functions, including the regulation of blood pressure, muscle and nerve function, and the development of bones and teeth [31]. In water, magnesium is typically found in the form of magnesium ions (Mg^{2}). The concentration of magnesium in groundwater and surface water varies depending on the geology and geographical characteristics of the area.

Water containing adequate levels of magnesium may offer certain health benefits. Several studies have suggested that the consumption of magnesium-rich water may be associated with a reduced risk of cardiovascular diseases, type 2 diabetes, and other health conditions [32].

However, excessive concentrations of magnesium in water can have undesirable effects, particularly regarding water quality and domestic use. Hard water, which contains high levels of magnesium and calcium ions, can lead to limescale deposits in household appliances, pipes, and plumbing systems, reducing their efficiency and lifespan [33].

Our results show that magnesium is removed from water in small quantities using mango seed shell powder, with a reduction of approximately 5 mg/L (Figure 9).

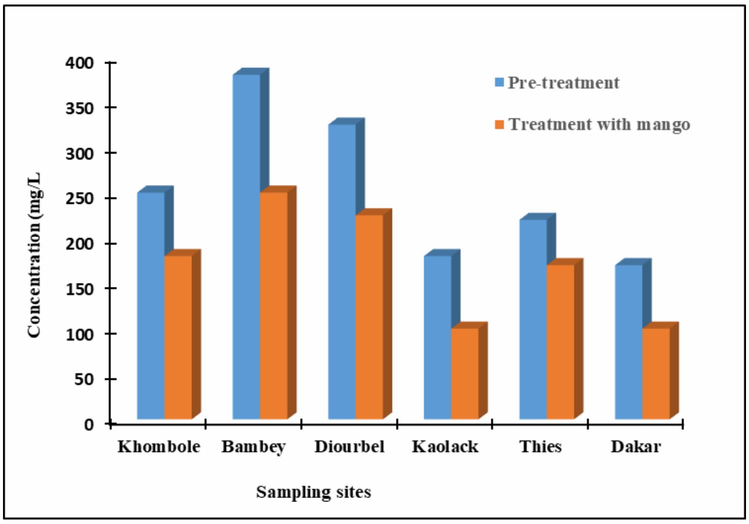

Figure 9: Variation in magnesium content according to sampling sites.

IV. Conclusions

The removal of micropollutants from water represents a major challenge in ensuring the safety and quality of drinking water. Our study revealed that all analyzed water samples contained pollutants that compromise their overall quality. The use of biomaterials such as mango and cassava offers a promising and environmentally friendly solution for addressing these contaminants. These materials are natural, renewable, and locally available in many parts of the world, making them cost-effective and sustainable options for water decontamination.

Our previous research [34] demonstrated that this biomaterial can effectively remove a wide range of micropollutants, including heavy metals, organic compounds, and mineral residues. Its performance depends on several factors, such as the preparation method of the biomaterial, treatment conditions, and the concentration of pollutants present in the water.

However, it is important to emphasize that the use of biomaterials for water treatment requires thorough evaluation to ensure their safety, effectiveness, and environmental impact. Further research is needed to optimize the application methods of these biomaterials and to assess their performance on a larger scale.

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