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Research Article

Improving Irrigation Water Quality with Local Filters in Akungba - Akoko, Southwest, Nigeria

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Abstract

The shortage of freshwater for irrigating vegetables in Akungba Akoko, Nigeria, is a critical concern during the dry season, demanding urgent attention. Local farmers rely heavily on polluted well and stream water for irrigation, which poses significant health risks due to contamination from refuse and pollutants. Addressing this challenge requires the development of a simple, cost-effective treatment facility to remove contaminants and make the water suitable for irrigation. This research aimed to assess the effectiveness of a straightforward filtration system using various physical materials to improve water quality. Conducted at Adekunle Ajasin University, Akungba-Akoko, the study focused on evaluating granite and river sand filtration on water collected from a local stream at Ibaka, Akungba-Akoko in April 7th, 2023. The filtered and unfiltered waters, categorized as follows: T_0 = Borehole water (Control), T_1 = Unfiltered water, T_2 = water filtered with granite, T_3 = water filtered with pure river sand, and T_4 = water filtered with combined physical filters were subjected to physicochemical and microbiological analyses to determine its suitability for irrigation purposes. The study revealed that using single or combined physical filtration materials led to a notable decrease in microbial levels in the water samples. Additionally, significant reductions in total solids (TS), total suspended solids (TSS), and total dissolved solids (TDS) were observed in water filtered through these materials, either alone or in combination. Granite filtration (T_2) resulted in notably higher pH (5.57 Ms/cm), EC (172.00 µ. S/cm) and nitrogen (27.00 mg/L) levels, while combined filtration (granite and pure river sand) (T_4) showed higher levels of phosphorus (9.35 mg/L). These findings demonstrate the efficacy of both singular and combined physical filtration materials in improving wastewater quality. Thus, employing these filtration methods, either individually or in combination, is recommended for local farmers, especially in Akungba Akoko, South West Nigeria, to enhance water quality for agricultural purposes.

Keywords

Waste Water, Physiochemical, Contamination, Filtration, Akungba-Akoko

1. Introduction

The shortage of freshwater for irrigating vegetables during the dry season poses a pressing issue for local farmers in Akungba Akoko, South West, Nigeria. This matter requires urgent attention. The dry season in the region is marked by a substantial increase in the prices of vegetables and other food crops, primarily attributed to the insufficient water available for crop irrigation. Local farmers heavily rely on water sourced from wells and local streams for irrigation, yet these water sources are extensively polluted due to the dumping of refuse and other pollutants. The contamination of these water

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sources further exacerbates the challenges faced by farmers in sustaining their agricultural practices. The indiscriminate discharge of domestic wastewaters into rivers and lakes without adequate treatment has resulted in contamination of water bodies in this area. According to Anju, A., Ravi et al. [1], insufficiently treated wastewater discharged to water-bodies can result in heavy contamination of the water bodies, resulting into serious environmental and health issues. Contamination of water bodies has become a global concern as a result of the growing world population of the which is in boundless need of fresh water [2].

Application of untreated or poorly treated polluted waters to vegetables could result in a number of problems such as pathogenic infection and accumulation of toxic substances both in the soil, crops, and underground water [3]. Zavadil [4] reported that direct application of untreated wastewater on crop land is associated with risks, such as crop yields reduction, crop quality deterioration, contamination of crops with pathogens and intestinal helminthes. Therefore, in order to reduce the health hazards and damage to the natural environment, polluted waters should be treated before reuse, especially for agricultural purposes [5]. Water quality requirements for irrigation is a subject of much interest; agricultural water should have potable quality, in physical, chemical and microbiological properties [6]. Waste water reuse in agriculture is expected to comply with re-use standards to minimize environmental and health risks [6].

Various physical filtration materials and methods have been explored to improve the quality of agricultural wastewater, aiming to remove suspended solids, contaminants, and pathogens. Sand filtration is one of the common filtration methods which involves passing wastewater through a bed of sand to trap suspended solids and impurities. Studies, such as that by Sato *et al*. [7], have explored the efficiency of sand filtration in removing particles and pathogens from agricultural wastewater. Research, such as the study by Mara [8], has explored the application of gravel filtration in decentralized wastewater treatment systems for agricultural use. Schellingerhout *et al.* [9], have investigated the removal efficiency of microscreen filtration in treating agricultural runoff. The study by Ma *et al*. [10] investigated the application of disk filtration in removing particulate matter from agricultural drainage water. Schwab *et al.* [11], studies have explored the efficiency of screen filtration in removing particles and pathogens from agricultural runoff. These studies demonstrate the diversity of physical filtration materials and methods applied to agricultural wastewater treatment, highlighting their potential in improving water quality for safe and sustainable reuse in agriculture.

Furthermore, Akinbuwa and Agele [12] demonstrated the application of sole and combined filtration materials such as granite, rice husk, charcoal and pure river sand on wastewater. They found out that application of combined filtration materials improved the quality of the water better than when the sole application was used. Hence, this study was conducted to explore and assess a simple and cost-effective treatment facility that can be readily adopted by low-income farmers in Akungba-Akoko, Ondo State, Nigeria for the treatment of Municipal stream water intended for vegetable production.

2. Materials and Methods

2.1. Study Site

This research was conducted at the Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria.

2.2. Water Source

The water was collected from a polluted local stream situated along Ibaka Street, Akungba-Akoko, Ondo State on April 7th, 2023.

2.3. Materials for Physical Filtration

Materials utilized for physical filtration included: i. Granite; and ii. Pure river sand.

2.4. Water Treatment

A sufficient volume of wastewater was collected and allowed to settle in three separate clean basins for 24 hours (Figure 2). Solid and heavy particles that settled at the bottom of the basins were removed, and the water was carefully decanted into another set of three separate basins. The decanted waters underwent physical filtration using filtration materials solely and in combinations (Figure 3). The filtration materials were applied in layers in the constructed filtration facility (Figure 1).

Figure 1. *Arrangement of the filtration materials in the sole and combined filtration facility.*

Figure 2. *Primary Water Treatment (PWT) In the initial phase of water treatment, the polluted water was allowed to settle, facilitating the process of decantation.*

Figure 3. *Constructed filtration facility Secondary water treatment (SWT) the decanted water underwent physical filtration using filtration materials solely and in combinations.*

Analysis of Filtered and Unfiltered Waters

The filtered and unfiltered waters, categorized as follows: T_0 = Borehole water (Control), T_1 = Unfiltered water, T_2 = water filtered with granite, T_3 = water filtered with pure river sand, and T_4 = municipal water filtered with combined physical filters, were subjected to chemical analysis (pH, electrical conductivity (EC), Nitrate, P, Ca, and Mg), physical analysis (Total Suspended Solid (TSS), total dissolved solid (TDS), total solids (TS)), and microbial analysis (Total faecal coliforms, Total Bacteria, and E. coli). The pH of each water samples was determined using Metro pH meter model E250, and the EC was measured using conductivity meter. Total solids, dissolved solids and suspended solids were determined using the AOAC method of analysis [13]. Chloride ion in water samples was measured titrimentrically using the Mohr's method. Calcium and magnesium ions in water samples were determined using the EDTA titration method. Nitrate concentration in water samples was determined by sodium hydroxide colorimetric method.

The total heterotrophic bacterial count was conducted on nutrient agar plates. Water samples underwent serial dilution, and 0.1 ml aliquots were plated on solidified-dried medium. Incubation was carried out upside down at 37 ℃ for 48 hours. For total coliform count, the Most Probable Number (MPN) technique with MacConkey broth was used. Faecal coliforms were estimated using Eosin Methylene Blue (EMB) Agar. Incubation occurred at 37 ℃ and 44 ℃ for 48 hours. The 5-tube MPN technique was employed for total coliform counts, interpreted using the corresponding table and recorded as MPN/100 ml. Data obtained from the analyses were subjected to One-way ANOVA and means were separated with Tukey HSD test at 5% level of probability using SPSS 24.0 version.

3. Results and Discussions

Comparing the microbial and physicochemical characteristics of treated water to untreated samples revealed enhanced water quality without adverse effects. The use of physical filtration materials such as granite and pure river sand, either individually or combined, led to significant reductions in microbial loads (including total faecal coliforms, E. coli, and total bacteria) post-treatment (Table 1). Notably, the greatest reductions in microbes were observed in waters filtered with combined physical filters (T_4), while untreated waters (T_1) exhibited the highest microbial load compared to other treatments. The borehole water (control = T_0) demonstrated the lowest values for total faecal coliforms (24 MPN/100ml), E. coli (22 CFU/ml), and total bacteria (120 CFU/ml).

Various filtration materials, such as sand, peat, wood by-products, biochar, coconut shells, and glass beads, along with other commercially available options, have been reported to effectively decrease microbial loads [14]. Previous studies have shown significant removal of bacteria and protozoa through filtration processes [15, 16], including efficient removal of *V. cholerae* and notable reductions in microbiological contamination [17]. Particularly, the combined use of physical filtration materials, as observed in T_4, resulted in significant reductions in microbial loads, consistent with earlier findings [18].

The impacts of treatment methods on physical and chemical properties are detailed in Tables 2 and 3. Significant reductions in Total Solids (TS), Total Dissolved Solids (TDS), and Total Suspended Solids (TSS) were observed in waters filtered with physical filtration materials, both individually and in combination (refer to Table 2). The untreated water (T_1) displayed the highest values of TS (0.91), TDS (0.86), and TSS (0.05) respectively, while the control treatment (Borehole water = T_0) exhibited the lowest values for TS (0.33), TDS (0.32), and TSS (0.01). Similarly, significant variations in chemical properties were noted among the treatments (Table 3). The pH levels varied significantly across the treatments, with the highest pH (5.57) recorded in T_2 and the lowest (5.39) in untreated wastewater (T_1). Furthermore, T_2 recorded the highest levels of Ca and Mg, while the highest Nitrate was observed in T_2, and the highest significant P was obtained in T_2 and T_3.

The pH of the treated waters complied with standards and guidelines for safe wastewater reuse in agriculture. The application of physical filtration materials, both individually and combined, resulted in significant reductions in TS, TDS, and TSS, consistent with findings in previous studies [19, 20]. The treated wastewater met recommended FAO and WHO standards for agriculture and safe disposal, with reduced electrical conductivity (EC) and chloride concentrations. The study also observed nitrate, Ca, Mg, and P levels in treated wastewater within WHO guidelines.

Table 1. *Microbial analysis of filtered and unfiltered water.*

Water	Total Faecal Coliforms MPN/100ml	E. Coli CFU/ml	Total Bacterial CFU/ml
T_0	24.00^{a}	22.00^{a}	120.00^{a}
T_1	350.00^{e}	245.00^{e}	660.00^{d}
T_2	145.00^{d}	150.00^{d}	300.00^{c}
T_3	105.00^{c}	90.00^{bc}	200.00^{b}
T_4	60.00^{ab}	76.00^{b}	140.00^{ab}

Mean with the same letter (s) in superscript on the same column are not significantly different at p=0.05 (Tukey HSD). To Borehole water (Control), T_1 = unfiltered water, T_2 = water filtered with granite, T_3 = water filtered with pure river sand, T_4 = water filtered with combined physical filters.

Table 2. *Physical properties of filtered and unfiltered waste waters.*

Water	Total Solid (mg/l)	Total dissolved Solid (mg/l)	Total suspended Solid (mg/l)
T_0	0.33^{a}	0.32^{a}	0.01^{a}
T_1	0.91^{d}	0.86^{d}	0.05^{c}
T_2	0.49	0.47^{b}	0.02^{a}
T_3	0.70^{c}	0.66	0.04^{b}
T_4	0.41^{ab}	0.38^{ab}	0.03^{ab}
WHO	-	500.00	-

Mean with the same letter (s) in superscript on the same column are not significantly different at p=0.05 (Tukey HSD). To Borehole water (Control), T_1 = unfiltered water, T_2 = water filtered with granite, T_3 = water filtered with pure river sand, T_4 = water filtered with combined physical filters.

Table 3. Chemical Properties of filtered and unfiltered wastewaters.

Waste source	pH (Ms/cm)	EC (µ. S/cm)	N (mg/I)	Ca (mg/l)	Mg (ppm)	P (mg/I)
$T_θ$	5.48^a	160.0^a	23.50^b	10.50^a	64.40^c	8.45^{ab}
T_1	5.39^a	164.00^{ab}	10.90^a	77.30d	60.40^c	8.23^{ab}
T_2	5.57^a	172.00^b	27.00^b	30.50^b	10.50^a	9.10^b
T_3	5.52^a	156.00^{ab}	20.70^b	58.10^c	48.50^b	7.59^a
T_4	5.40^a	170.00^b	24.50^b	57.50^c	47.50^b	9.35^b
WHO	6.5-8.5	1400.00	10.00	75.00	50.00	200.00

Mean with the same letter (s) in superscript on the same column are not significantly different at p=0.05 (Tukey HSD). To Borehole water (Control), T1 = unfiltered water, T2 = water filtered with granite, T3 = water filtered with pure river sand, T4 = water filtered with combined physical filters.

4. Conclusion

The results of this research indicate that using singular and combined filtration materials leads to enhancements in the quality parameters of water. Therefore, adopting these physical filtration materials, either individually or in combination, improves the overall quality of water. This practice is highly recommended for local farmers, especially those in Akungba Akoko, South West Nigeria, to ensure better water management and agricultural sustainability in the region. However, it is necessary to further investigate the quality of water used on crops. This includes analyzing potential contaminants, assessing the impact on crop health and yield, and ensuring compliance with safety standards. Additionally, the long-term effects of using this water on soil quality and the surrounding ecosystem should be examined. Understanding these factors is crucial for maintaining sustainable agricultural practices and protecting consumer health.

Abbreviations

TS	Total Solids
TSS	Total Suspended Solids
TDS	Total Dissolved Solids

Author Contributions

Olumakinde Akinbuwa is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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