Physicochemical and Microbiological Qualities of Water and Soil Samples from Groundnut Oil Producing Industry

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Authors' contributions

All authors contributed to the work presented in this paper. Authors AB executed the research and collated the data. Authors DOA and OAM drafted the first manuscript. Author CAO supervised the research and interpreted the data. Author CAO conceptualized and prepared the final manuscript draft. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Triplicate tap and wastewater samples collected from a groundnut oil producing industry in Akure metropolis, Southwest Nigeria were analysed for physicochemical and microbiological qualities using standard procedure. Adjoining soil samples were aseptically collected and serially diluted for total coliform counts using most probable number method. The range of the physicochemical qualities of the tap water and wastewater are as follows: pH (5.7-6.8), colour (4.98-90.0 HU), nitrite (1.6-20.0 mg/l), alkalinity (0.02-52.0 mg/l), BOD (1.79-2.87 mg/l) and TDS (1.59-33.0 mg/l); while for the soil samples, they are as follows: pH (6.7), alkalinity (32 mg/l), nitrate (9.98 mg/l), phosphate (15 mg/l) and total organic carbon (2.74 mg/l). Total coliforms ranged in the order of 10^4 to 10^5 cfu/ml and 10^4 to 10^5 cfu/g for tap water and soil samples respectively. The bacterial pathogens recovered from the water and soil samples include: *Escherichia coli*, *Klebsiella* spp., *Pseudomonas* spp.,

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Bacillus spp., *Proteus* spp., *Shigella* spp., *Enterobacter* spp., *Staphylococcus aureus*, *Streptococcus* spp. and *Salmonella* spp., while the fungal isolates included *Fusarium*, spp., *Aspergillus* spp. and *Penicillium* spp. We conclude that the groundnut wastewater is important point sources of pollution in surface water with potential public health and ecological risks.

1. INTRODUCTION

Freshwater resource is a scarce and unevenly distributed resource, with no direct relation to the development patterns of human societies. Water is crucial for all aspects of life, as it is essential for domestic, recreational and industrial purposes and has become a source of economic and political power [1]. Ninety seven and a half per cent (97.5%) of all water is found in the oceans; of the remaining freshwater only one percent (1%) is available for human's domestic and industrial needs [2]. A healthy and functional aquatic ecosystem provides us with a myriad of services which range from food, medicines, recreational facilities, and waste management [3].

Groundnut oil producing industries, like other industry, make use of water on a daily basis and generate wastewater that are either treated or untreated before being discharged into the environment. According to the [4], partially or untreated effluents can be a source of pollution, a hazard for the receiving waterbodies and all other ecosystems that depend on the environment. Wastewater can be contaminated with an array of constituents: pathogens, organic compounds, synthetic chemicals, organic matter and heavy metals. They are either in solution or as particulate matter and are carried along in the water from different sources thus impacting water quality [5]. These constituents of wastewater can have cumulative, constant and synergistic characteristics that are capable of affecting the ecosystem health and function, human and animal health, and food production and security [6,7]. This research was designed to reveal the impact of partially and untreated effluents from a groundnut oil processing industry in Akure metropolis, Nigeria, on the physicochemical and microbiological properties of the receiving water bodies.

2. MATERIALS AND METHODS

2.1 Samples Collection

The following samples were randomly and aseptically collected from a groundnut oil producing industry in Akure, South-western Nigeria: water sample from the source, wastewater generated from the industry and adjourning soil sample. The samples were randomly collected. The water from the source was from a running tap, the wastewater sample was collected against the flow of water with sterile bottle according [8] and the adjourning soil was collected along the surface of the running wastewater and immediately transported to the laboratory for further physicochemical and microbiological analyses.

2.2 Physicochemical Analysis

Physicochemical analysis of parameters such as pH, temperature, colour and odour were carried out *in situ*. The samples were immediately placed in a lightproof insulated box containing ice-packs and transported to Microbiology laboratory at the Adekunle Ajasin University, Akungba-Akoko through a journey of about 2 h. Upon arrival, the samples were immediately stored at 4℃ until processing. Analysis of water-quality parameters which includes: total dissolved solids (TDS, mg/L), nitrate (NO_3, mg/L), phosphate (mg/L), total suspended solids (TSS, mg/L), biochemical oxygen demand (BOD, mg of O_2/L), chemical oxygen demand (COD, mg of O_2/L), and total solids (TS, mg/L) were carried out using standard methods of [9].

2.3 Culture Media

The culture media used for this research work were Nutrient Agar (NA), Eosin Methylene Blue Agar (EMB), MacConkey Agar (MAC) for bacterial analysis and Potato Dextrose Agar (PDA) for fungal analysis. The media were prepared and sterilized according to the manufacturer's specification.

2.4 Isolation and Identification of Microorganisms

Ten (10) grams of each soil sample was diluted in 90ml of sterile distilled water in a conical flask to get the aliquot, and a tenfold serial dilution was carried out. Ten (10) ml of the water samples were also serially diluted up to dilution

factor of 10^{-6}. An aliquot of 1ml from selected dilutions of each sample was inoculated aseptically into labelled triplicate agar plates of the media (NA, MAC, EMB) using standard pour plate method and incubated at 37℃ for 24 -48 hours; Potato Dextrose Agar incubated at room temperature for 5 days for the isolation of fungi. The cultural characteristics observed include shapes, surface, elevation, edge and colour of the microbial growth. Microbial colonies were counted and recorded. Presumptive isolates were preserved on appropriate agar slants stored at 4℃ for further analysis. Presumptive isolates were further characterized and identified using cultural and morphological characteristics as well as biochemical tests.

2.5 Identification of Fungi Isolates

Identification of fungal isolates was done using lactophenol in cotton blue stain. The stained slides were examined with the aid of a microscope, focused with ×10 objective and viewed with ×40 objective lens as described by [10]

3. RESULTS

The results of the physicochemical parameters of the studied samples are shown in Table 1. The pH of the tap water, wastewater and soil samples was 5.70, 6.79 and 6.73 respectively. Tap source had an alkalinity value of 52.02 mg/l, the wastewater had 0.02 mg/L while the adjoining soil had 32.0 mg/L. Wastewater had the highest nitrate present (19.98 mg/L) while the tap water had the lowest nitrate value (1.60 mg/L). Tap water had the lowest total dissolved solids was 1.59 mg/L while the wastewater highest was 32.99 mg/L. The colour of the tap water was the lowest (4.98 HU) while wastewater had the highest value (89.99 HU). The biological oxygen demand (BOD) for tap water and wastewater ranged from 1.79 mg/L to 2.87 mg/L. There was significant difference between the values of physicochemical parameters observed in studied tap water, wastewater and soil sample at $P \leq 0.05$.

Table 2 shows the microbial loads of the water samples. The mean *Escherichia coli*, total coliforms and total viable bacteria count exceeded the acceptable limit for the tap water and adjoin soil samples. The wastewater had the highest total viable bacteria count being too numerous to count with lowest count being 9.0×10^4 cfu/ml (water source). The total coliform counts for tap water and wastewater ranged were 7.0×10^4 cfu/ml and 3.0×10^6 cfu/ml respectively. The highest *Escherichia coli* were observed in wastewater (2.9×10^6 cfu/ml) and adjoining soil (3.8 cfu/g). Tables 3 shows the occurrence of bacterial isolates from tap water, wastewater and adjoining soil samples. Bacteria isolated from these samples included *Escherichia coli*, *Pseudomonas* species, *Bacillus* species, *Proteus vulgaris*, *Shigella* species, *Enterobacter aerogenes*, *Staphylococcus* species, *Klebsiella* species, *Streptococcus* species and *Salmonella* species. The fungal counts are as presented in Table 4. Different species of fungi obtained on Potato Dextrose Agar included: *Penicillum* spp., *Aspergillus* spp and *Rhizopus* spp.

Table 1. Physicochemical analysis of tap water, wastewater and adjoining soil

Parameter	Tap Water	Wastewater	Adjoining soil
pH	6.79 ± 0.03	5.70 ± 0.03	6.73 ± 0.09
Total Dissolved Solids (mg/l)	1.59 ± 0.02	32.99 ± 0.02	NA
Colour (Hazen Unit)	4.98 ± 0.02	89.99 ± 0.01	NA
Alkalinity (mg/l)	52.02 ± 0.02	0.02 ± 0.01	32.00 ±0.04
Nitrate (mg/l)	1.60 ± 0.03	19.98 ± 0.02	9.98 ± 0.06
Phosphate (mg/l)	NA	NA	14.99 ± 0.02
Total Suspended Solids (mg/L)	3.97 ± 0.02	1.10 ± 0.03	NA
Biochemical Oxygen Demand (mg/L)	1.79 ± 0.02	2.87 ± 0.54	NA
Total Organic Carbon (%)	NA	NA	2.74 ± 0.02
Lead (mg/L)	NA	NA	0.98 ± 0.02
Copper (mg/L)	0.02 ± 0.01	0.10 ± 0.01	0.09 ± 0.03

Key: NA- Not applicable

Table 2. Total bacterial counts on different media

Sample	NA	EMB	MAC
Tap water	9.0×10^4	5.0×10^4	7.0×10^4
Wastewater	TNC	2.9×10^6	3.0×10^6
Adjoining soil	3.2×10^6	3.8×10^6	2.8×10^6

Key: NA = Nutrient agar, EMB = Eosin methylene blue agar
MAC = MacConkey agar, TNC = Too numerous to count

Table 3. Bacterial Isolates From tap source, wastewater and adjoining soil samples

Bacterium	Tap Water	Waste-water	Adjoining soil
Bacillus spp	-	+	+
Enterobacter aerogenes	-	+	+
Escherichia coli	+	+	+
Proteus vulgaris	-	-	+
Pseudomonas spp	-	+	+
Salmonella spp	-	+	+
Shigella spp	-	+	+
Staphylococcus aureus	+	+	+
Staphylococcus spp	-	+	+
Streptococcus spp	-	-	+

Key: + = Present, -= Absent

4. DISCUSSION

The microbiological and physicochemical parameters of the tap water, wastewater and adjourning soil of a groundnut oil producing industry were evaluated in this study. Physicochemical analysis of the wastewater revealed that the pH was 5.70 with a strong choking odour emitted. Biological oxygen demand (BOD) concentrations of the tap water and wastewater were observed to be low. However, it must be noted that BOD usually becomes problematic when it becomes higher than 5 mg/L and especially when it is in combination with large volume of total dissolved solids, which could lead to clogging of soil [11]. It has been reported that each of the physicochemical parameters analysed has synergetic effects on the others, which has some impact on water quality, as well as the use of the water [12]. The level of total solids in the wastewater is most probably due to the presence of spent groundnut particles and high dissolved organic matter content of the wastewater from the industry. The mean value of total dissolved solids of the discharged effluent was much lower than the stipulated limit of 2000 mg/L [13]. Elevated levels of nitrates can result in eutrophication, giving rise to increase algae growth and eventually leading to reduced dissolved oxygen levels in the water [14].

In rural areas of developing countries, the great majority of health-related water quality problems are the result of bacteriological or other biological contamination. The presence or abundance of faecal coliform in wastewater final effluents is a feeble index of the presence of human pathogens in wastewater entering environmental waters. Regardless of this, utilization of faecal coliforms for water quality testing purposes is universal [15].The presence of high counts of enteric bacteria suggests the possible presence of potential pathogens in the tap water, and in this regard the effluent and tap water poses a serious threat to the receiving waterbodies and its entire ecosystem. In a study by [16], it was demonstrated that these enteric microorganisms are of huge public health concern, and as such water containing them must be treated properly before use or before being discharged into the environment. The high enteric bacterial counts indicate poor sanitary and unhygienic practices in the industry's environment, and this poses risk to the final product and receiving water bodies around the industry. The presence of bacterial species such as *Escherichia*, *Pseudomonas* and *Streptococcus* in some of the cultured samples indicates a contamination which may be related to human and animal activities in the environment and mostly from faecal origin. The presence of *Staphylococcus aureus* in the water source could be attributed to the improper handling from workers, as *S. aureus* is a normal flora of the human skin and mucosal membranes [17]. This poses a serious public health hazard, capable of causing water-borne diseases outbreaks. In a study carried out by [18], the authors established the tendency of enteric pathogens moving from surface to the underground water, and emphasised the importance of the intensity of water flow and the number of water applications to the movement. Therefore, improper discharge of this wastewater could lead to contamination of underground water.

Table 4. Total Fungal Count and morphological characteristics

Plate	Number of colonies on plate (cfu/g)	Shape of colonies	Colour of colonies
FA_1	2×10^2	Oval, irregular	Brown, creamy
FA_2	1×10^3	Round, circular	Black
FB_1	9×10^2	Circular, regular	Creamy, yellowish, brown
FB_2	7×10^3	Oval, circular	Brown, black
FAs_1	5×10^2	Circular, round	White, black underlay
FAs_2	4×10^3	Irregular	White, black
Control	0	No growth	No colour

Key: FA = Water source fungi, FB = Wastewater fungi, FAs = Soil fungi

5. CONCLUSION

The ongoing problems facing the water and sanitation body in Nigeria is still a major public health threat; dearth of access to portable water, waterborne diseases and faecal pollution to freshwater highlight the need for the Nigeria sanitation agency to begin to revise current guidelines to meet acceptable standards set by other developed nations. The groundnut oil industry fared poorly in the treatment of its wastewater, and this result reveals the severe pollution resulting from the elevated levels of organic nutrients in the final effluent. The non-compliance of the groundnut oil processing industry presents it as a plant that poses a potential danger to public health. Thus the outcome of this study definitely suggests an urgent need for pollutant reduction inputs into surface water and the need to upgrade existing wastewater management regulations.

DISCLAIMER

Some part of this manuscript was previously presented in the following conference.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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