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Assessment of Heavy Metal Bioremediation Potential of Microbial Isolates Collected from Wupa Wastewater Treatment Plant Abuja. Évaluation Du Potentiel De Biorestauration Des Métaux Lourds Des Isolats Microbiens Prélevés Dans La Station D'épuration Des Eaux Usées De Wupa, Abuja.

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ABSTRACT

Background: *Municipal wastewater is a major source of pollution, accumulating contaminants into sludge. Discharge reduces dissolved oxygen levels and nutrient enrichment, allowing microorganisms to survive. Utilizing microorganisms to clean up the environment is known as bioremediation. Because it is safe, effective, and environmentally benign, biological treatment has been the method of choice for metal remediation in wastewater. This study was conducted to assess the physicochemical and microbial characteristics of Wupa wastewater and the potential of indigenous microbes in the bioremediation of heavy metals.*

Materials and Methods: *Samples of wastewater from the Wupa Abuja treatment plant were analyzed for physicochemical parameters, including pH, electrical conductivity, and oxygen demand. Bacteria and fungi were isolated, and their bioremediation potential was assessed using a heavy metal solution.*

Results: *The study found significant differences in physicochemical parameters between treated and untreated wastewater, except for pH and temperature. Heavy metals showed significant differences between influent and effluent, with manganese, iron, and zinc values varying. Eight bacterial and fungi species were isolated, with Aspergillus terreus having the highest bioremediation potential. Duganella callida had the highest absorbance.*

Conclusion: *The Wupa Wastewater Treatment Plant's assessment of microbial communities revealed potential for heavy metal remediation, serving as a baseline for removing toxic metals*

ABSTRAIT

Contexte: *Les eaux usées municipales sont une source majeure de pollution, accumulant des contaminants dans les boues. La décharge réduit les niveaux d'oxygène dissous et l'enrichissement en nutriments, ce qui permet aux micro-organismes de survivre. L'utilisation de micro-organismes pour nettoyer l'environnement est connue sous le nom de bioremédiation. Parce qu'il est sûr, efficace et sans danger pour l'environnement, le traitement biologique a été la méthode de choix pour l'assainissement des métaux dans les eaux usées. Cette étude a été menée afin d'évaluer les caractéristiques physicochimiques et microbiennes des eaux usées de Wupa et le potentiel des microbes indigènes dans la bioremédiation des métaux lourds.*

Matériaux et méthodes: *Des échantillons d'eaux usées de la station d'épuration de Wupa Abuja ont été analysés pour les paramètres physico-chimiques, notamment le pH, la conductivité électrique et la demande en oxygène. Les bactéries et les champignons ont été isolés, et leur potentiel de biorestauration a été évalué à l'aide d'une solution de métaux lourds.*

Résultats: *L'étude a révélé des différences significatives dans les paramètres physico-chimiques entre les eaux usées traitées et non traitées, à l'exception du pH et de la température. Les métaux lourds présentaient des différences significatives entre l'affluent et l'effluent, les valeurs de manganèse, de fer et de zinc variant. Huit espèces de bactéries et de champignons ont été isolées, Aspergillus terreus avant le potentiel de biorestauration le plus élevé. Duganella callida avait l'absorbance la plus élevée.*

Conclusion: *L'évaluation des communautés microbiennes par l'usine de traitement des eaux usées de Wupa a révélé un potentiel d'assainissement des métaux lourds, servant de référence pour l'élimination des métaux toxiques.*

Mots-clés: *Eaux usées, Microbes, Métaux lourds, Bioremédiation*

INTRODUCTION

Wastewater generated from the municipal water treatment plant is one of the main sources of pollution to aquatic life, plants, soil, and the environment (1,2). Various contaminants in the wastewater usually accumulate to give what is known as sludge, and discharge of this sludge into the water bodies usually increases the organic load tremendously thereby reducing the dissolved oxygen levels and nutrient enrichment which helps the microorganisms in the wastewater to survive (3). In most cases, the methods commonly used in the treatment of wastewater in the Wupa treatment plant, do not guarantee the quantitative removal of many contaminants. Sometimes equipment failure of accessories such as dosing pumps and blower machine power failure could result in the discharge of waste containing contaminants into the environment, causing pollution (4).

Pollution of wastewater can be caused by chemical, biological, and mechanical pollution (5). The chemical pollutants in wastewater include; heavy metals, hydrocarbon pesticides, and nitrogen and phosphorus compounds. Others are residues from pharmaceuticals, detergent pollutants, and animal or human fecal waste containing different types of disease-causing protozoa, viruses, and bacteria. While mechanical pollutants could arise due to leaking pumps, and faulty machines discharging lubricants into the wastewater (6).

Heavy metals are a general collective term that applies to the group of metals and metalloids with an atomic mass density of 4000kgm-3 and about 3-5 times more than water (7). Some heavy metals are purely toxic with an unknown role, while others are essential to man at low concentrations but become toxic at high concentrations, a result of contamination of the wastewater (8). Heavy metals generally found in water include Chromium (Cr), Copper (Cu), Nickel (Ni), iron (Fe), Zinc (Zn) Cadmium (Cd), Molybdenum (Mo), etc. These metals are from chemical and agricultural wastes discharged from industries and municipal waste from households and hospitals (9).

Bioremediation is a process that involves the use of microorganisms for environmental clean-up. Over the years, the use of biological treatment has been preferred over chemical treatment such as filtration, acid leaching, and ion exchange for metal remediation in wastewater because it is non-toxic, efficient, and eco-friendly (7). The Wupa wastewater treatment plant receives about 131,250 m3 of wastewater daily during the dry season. It was designed to meet the requirement of 700,000 population equivalence (10). The major challenge faced by the plant is the lack of constant power supply despite the standby generator set and maintenance of equipment, resulting in the discharge of untreated wastewater into the Wupa River (10). This study assessed the heavy metal bioremediation potential of microbial isolates at the Wupa wastewater treatment plant in Abuja.

MATERIALS AND METHODS

Study Area

The study was carried out at the Wupa Wastewater Treatment Plant Abuja, (WWTP) Nigeria between December 2022 and August 2023. The WWTP is situated in the Idu district of the Abuja Municipal Area Council (AMAC) at coordinates 7°23“N, 9 °01E. Located behind the plant is the effluent-receiving river, the Wupa River. It was constructed to treat wastewater generated from Phases I, II, and III of the AMAC. It was designed to handle the wastewater generated by 700,000 Population Equivalent (PE) and expandable to 1,000,000 PE, thus, the plant can accommodate an average dry weather inflow of 5,500 cubic meters per hour and a wet weather inflow of 9,000 cubic meters per hour (10).

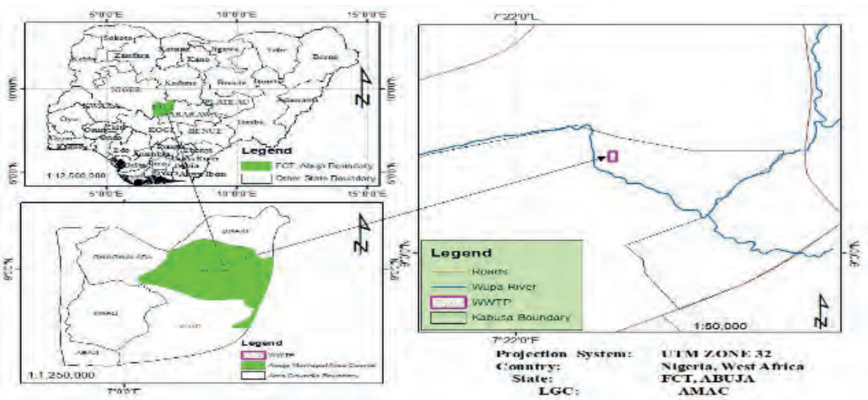


Figure 1: Map of the Federal Capital Territory showing the location of the Wupa Wastewater Treatment plant

Collection of Sample

Two different sampling sites at the Wupa wastewater treatment plant were selected for the study namely: (I) Untreated wastewater (influent)-just as it was discharged into the sewage treatment plant and (II) Treated wastewater (effluent)-just as it passes through the ultraviolet ray channel before it was discharged into the Wupa River. Wastewater samples were collected from the sampling points. The sampling points were opened and allowed to drain for 30 seconds after which the wastewater was collected aseptically using sterile 250ml sample bottles and corked immediately to avoid further contamination. The temperature of the wastewater samples was measured at the point of sample collection. Water samples were collected in triplicate for physicochemical parameters, microbial analysis, and heavy metals analysis (11).

Determination of Physiochemical Analysis of Wastewater (Effluent and Influent)

The physiochemical parameters of the wastewater collected from the WUPA treatment plant were analyzed using their respective analyzers and according to the manufacturer's instructions. The measured parameters include pH, turbidity, total dissolved Solid (TDS), total suspended solids (TSS), dissolved oxygen (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD) were determined in accordance with standard methods and procedures of American Public health association, (APHA). (12)

Determination of Heavy Metals Concentration in the wastewater

The wet method of digestion was used to carry out the analysis as described by APHA (12). 1ml of collected wastewater sample was added to 20ml of nitric acid and digested on a hot plate at 150 °C till samples were fully dissolved. Then 100ml of distilled water was added to the digested samples and it was then poured into labeled sample bottles for further analysis. An atomic absorption spectrophotometer was used to determine the level of various heavy metals (12).

Wastewater Sample Preparation for microbial analysis

Samples were prepared by using dilution factor and pouring them on a solidified prepared nutrient agar and potato dextrose agar (PDA). 1 ml of each wastewater sample was poured into a test tube containing 9 ml of distilled water as a stock, and nine other test tubes also containing 9 ml of distilled water were arranged serially in the test tube rack. 1 ml. of the stock was collected using a pipette to the first test tube and from the first test tube to the second test tube up to the ninth test tube respectively. The dilutions 10-5, 10-6, and 10-7 were used and 1 ml. was taken from each factor into a sterilized Petri dish in duplicates (13, 14).

Wastewater sample Inoculation using Spread Plate technique.

Exactly 10 ml of the Molten, and Sterile Nutrient agar for bacteria isolation and Sabouraud Dextrose Agar (SDA) for fungi isolation were dispensed into clean and sterile Petri dishes (20 for bacteria and 10 for fungi). The petri dish was rotated carefully to allow even distribution of the inoculum within the medium. This was then allowed to set and solidify. This was followed by the addition of 0.1 ml of each of the two dilutions (10-3 and 10^{-4}) into the plates. The Petri dishes (plates) were incubated at 35 – 37 °C anaerobically for 24 hours for bacteria and 25 °C – 27 °C for 7 days for fungi, and growth was observed daily. Distinct colonies were picked and sub-cultured severally into nutrient agar (NA) for bacteria and Sabouraud agar (SDA) for fungi until pure cultures were obtained. Pure cultures for bacteria were further inoculated into sterilized Bijou bottles containing media to avoid contamination. The pure colonies were used for morphological, cultural, biochemical, and molecular characterization according to Ochei et al., (13).

Colony Count of Bacteria Isolates

A Stuart SC6+ Colony Counter was used to count the number of bacterial cells that were able to grow within 24 hours on the nutrient agar plate after 24 hours of incubation. The sample colony forming unit (CFU) per mL was manually counted. Distinct colonies were picked and subcultured into nutrient agar for bacteria until pure cultures were obtained. The pure colonies were used for morphological, cultural, biochemical, and molecular characterization according to Ochei et al., (13).

Characterization and identification of isolates

Microscopic and culture methods were used for the identification of isolated microorganisms. They include gram staining (for bacteria), shape, and size of the microorganisms (for bacteria), and lactophenol cotton blue for fungi. The culture method was used to reveal the texture, color, and shape of both bacteria and fungi. Furthermore, the isolated bacteria were subjected to Gram staining and other biochemical tests such as sugar fermentation test (glucose, lactose, and sucrose), catalase test, coagulase test, indole test, motility test, citrate test, and methyl red test. Confirmatory identities of the bacteria were made using Bergey's Manual of Determinative Bacteriology while the mycology atlas was used for the identification of fungi (14).

Molecular characterization and phylogenetic analysis

The genomic DNA of axenic cultures of bacterial isolates was extracted using the ZR Fungal/Bacterial DNA Kit™ (Zymo Research, Irvine, CA) following the manufacturer's instructions at the biotechnology laboratory of Nile University of Nigeria, Abuja. The obtained DNA was then amplified using the 16S Ann Microbiol (2019) 69:541–551 543 rRNA universal gene primer set (27F and 1492R) under the following cycling conditions: an initial denaturation step at 98 °C for 3 min followed by 32 cycles of denaturation at 94 °C for 30s, annealing at 55 °C for 30 s and extension at 72 °C for 1 min followed by final extension at 72 °C for 10 min. The final PCR products were then purified and sequenced in the forward and reverse directions on the ABI PRISM™ 3500xl Genetic Analyzer. The obtained sequences were subjected to BLAST analysis for the identification of bacterial taxa and submitted to NCBI GenBank for the generation of accession numbers. Phylogenetic analysis was performed using the Molecular Evolutionary Genetics Analysis v7 (MEGA7) software using an alignment created with SINA Aligner.

Screening bacteria and fungi isolates bioremediation potentials.

Preparation of stock solution of heavy metals: Stock solution of iron, zinc, and manganese was prepared by dissolving 0.1g of iron, 0.1g of zinc, and 50ml of manganese solution in a sterile conical flask containing 500ml of distilled water for each respectively. The flask was warmed on a hot plate simultaneously with gentle shaking and sterilized at 121°C for 15 minutes in an autoclave. The solution was stored in a refrigerator at 4°C until needed (15).

Screening of microorganisms for potential to grow and utilize heavy metals: Indigenous bacteria and fungi isolates from wastewater were screened for their potential to utilize wastewater. Sterile nutrient agar and Sabouraud supplemented with a prepared stock solution of heavy metals were poured into sterile Petri dishes and allowed to solidify. Pure isolates were inoculated on heavy metal-supplemented agars. The Bacteria isolates were incubated at 35°C for 48 hours while the fungi isolates were incubated at room temperature (25±2o C) for 5 days. After the period of incubation, the plates were monitored for growth for seven days, and absorbance was measured using a Microplate reader (EMP M201) (16).

Statistical Analysis of Data

Using Microsoft Excel package 365, descriptive statistics were employed to represent the data generated from the physicochemical parameters. Experimental data were presented as mean ± standard error of the mean (SEM). The t-test was used to determine the significant difference ($p<0.05$) between two and more than two variables of the parameters using Statistical Package for Social Science (SPSS) 23.0.

RESULTS

Physicochemical Analysis of Wastewater

The mean values of physicochemical parameters determined in wastewater (influent and effluent) from Wupa WWTP as presented in Table 1 showed that pH was observed to be higher (7.25±0.03) in effluent while Mn, Fe, and Zn were observed to be reduced in the effluent. All measured physicochemical parameters of influent and effluent with the exception of water pH and temperature show significant differences ($p<0.05$) between the influent and effluent. The mean value of the studied heavy metal of the Wupa wastewater treatment plant presented in Table 1. showed that the mean value of manganese ranged from 0.31±0.10mg/L in the effluent to 0.37±0.20 mg/L in the influent. Manganese mean value shows a significant difference ($p<0.05$) between the influent and effluent as the effluent recorded lower values after treatment. Iron mean value ranged from 0.91±0.3mg/L in the effluent to 1.58±0.2mg/L in the influent. Iron mean value shows a significant difference ($p<0.05$) between influent and effluent as the effluent recorded lower values after treatment. Zinc mean value ranged from 0.501±0.10mg/L in the influent to 0.501±0.10mg/L in the effluent. The zinc mean value shows a significant difference ($p<0.05$) between the effluent and influent as the effluent recorded lower values after treatment. All the measured heavy metal influent and effluent were above the WHO limit for wastewater before discharge.

Table 1: Mean Physicochemical parameters of wastewater from WWTP

Parameters	Influent	Effluent	WHO Standard
pH	7.14±0.02	7.25±0.03	6.5 – 8.5
Temperature (0C)	27.3±0.01	29.4±0.02	<40
Conductivity (µs/cm)	53.4±0.02*	35.5±0.01	1250
Turbidity (NTU)	181.0±0.01*	24.0±0.03	<40
TDS (mg/L)	320.0±0.01*	213.1±0.01	300
BOD (mg/L)	41.0±0.01*	3.0±0.03	10
COD (mg/L)	77.9±0.01*	5.70±0.01	<5.0
TSS (mg/L)	149±0.03*	22.0±0.02	30
Manganese (mg/L)	0.37±0.10	0.31±0.020	0.05
Iron (mg/L)	1.58±0.20	0.91±0.30	0.3
Zinc (mg/L)	0.50±0.10	0.50±0.10	0.1

Bacteria isolate wastewater influent and effluent of the Wupa wastewater treatment plant.

The Mean bacteria colony count of bacteria isolates of wastewater influent was 1.32×10^{-4} while that of effluent ranged from 1.28×10^{-4} to 1.48×10^{-3} (Table 2).

Table 2: Mean bacteria colony count of bacteria isolates of wastewater influent and effluent of Wupa wastewater treatment plant.

Samples	Dilution factor	Number of colonies	Cfu/ml
Effluent	10^3	148	1.48×10^5
	10^4	128	1.28×10^6
Influent	10^3	TNTC	TNTC
	10^4	132	1.32×10^6

Note. TNTC: Too numerous to count

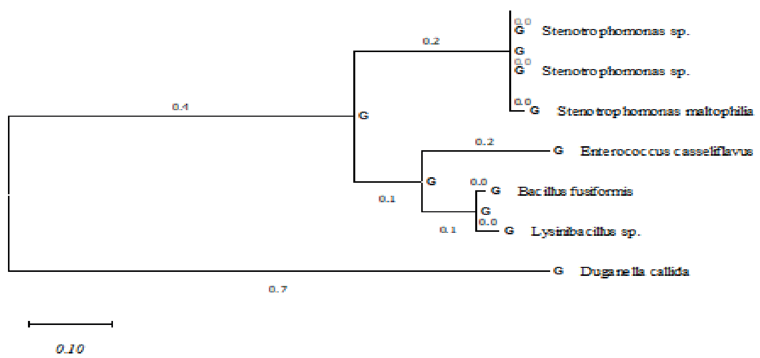
Molecular identification of Bacteria isolates from Wupa WWTP

The result of the bacteria sequence blast from the NCBI database presented in Table 4.4 showed that sample 1 had 98.17% similarities with Stenotrophomonas sp. with accession number MN493876.1. Sample 2 had 98.43% with Stenotrophomonas sp. strain MR107 98.43% with accession number MG674373.1. Isolate 3 had 91.84 with Bacillus fusiformis strain with accession number AY548954.1. Isolate 4 had 88.76% similarity with Stenotrophomonas maltophilia strain with accession number CP040436.1. Isolate 5 had 96.12% similarity with Lysinibacillus sp. strain with accession number MF465572.1. Isolate 6 had 90.54% similarity with Enterococcus casseliflavus strain with accession number MH899231.1. Isolate 7 had 98.82% similarity with Stenotrophomonas sp. 98.82% with accession number MN208463.1 and isolate 8 had 87.67% similarity with Duganella callida with accession number NZ_SPVG01000119.1. The obtained bacteria sequences were further used to construct a phylogenetic tree to ascertain the relationship between each species sequence as shown in Figure 2.

Table 3: Molecular identification of Bacteria isolates from Wupa WWTP

Isolate code	Accession number	Percentage	Organism
S1	MN493876.1	98.17%	Stenotrophomonas sp.
S2	MG674373.1	98.43%	Stenotrophomonas sp.
S3	AY548954.1	91.84	Bacillus fusiformis
S4	CP040436.1	88.76	Stenotrophomonas maltophilia
S5	MF465572.1	96.12%	Lysinibacillus sp.
S6	MH899231.1	90.54%	Enterococcus casseliflavus
S7	MN208463.1	. 98.82%	Stenotrophomonas sp
S8	NZ_SPVG01000119.1	87.67 %	Duganella callida

Figure 2 Phylogenetic tree of bacteria isolates from Wupa WWTP Abuja.



Fungi isolate wastewater influent and effluent of Wupa wastewater treatment plant.

A total of eight (8) fungi isolates were isolated and identified from wastewater sampled from the Wupa wastewater treatment plant, Abuja (Table 4.5). The fungi isolates were Penicillium ascomycetes, Penicillium chrysogenum, Aspergillus terreus, Trichophyton rubrum, Trichophyton martegrophyta, Trichophyton megninii, Trichophyton tonsurars and Penicillium spp.

Bioremediation Potentials of Isolated Microorganisms

The mean absorbance of indigenous fungi isolates, and growth are presented in Table 5. Aspergillus terreus had the highest bioremediation potential (0.904 ± 0.00) with maximum growth (+++) observed, Trichophyton rubrum (0.892 ± 0.11) with a maximum growth (+++) observed, Penicillium ascomycetes (0.577 ± 0.08) with a moderate growth (++) observed and Penicillium chrysogerum had the lowest bioremediation potential (0.473 ± 0.03) with a moderate growth (++) observed.

The mean absorbance of indigenous bacteria isolates and growth is presented in Table 6. Duganella callida had the highest absorbance with 1.402 the next was Enterococcus casseliflavus with 0.978, Stenotrophomonas maltophilia with 0.883, Bacillus fusiformis 0.704, and the lowest was Lysinibacillus sp. with 0.285.

Complete inhibition of growth of the organisms was represented by (-): indicating total heavy metal inhibition of the growth of the organisms, while scanty growth of the organisms incubated in heavy metal supplemented agar was depicted by (+). Moderate growth is denoted by (++) and exuberant growth is indicated by (+++): indicating no inhibition of the growth of the organism by heavy metal.

DISCUSSION

Water plays a key role in supporting all forms of life on Earth. Water acts as a solvent to dissolve the solutes of the human body and acts as a medium for undergoing many metabolic processes. Therefore, it is vital for all known forms of life (17). Nevertheless, if it is contaminated with a variety of contaminants as in sewage water or wastewater, it may become the place for the growth of different types of microorganisms which may have a potential for spreading a variety of diseases. All measured physicochemical parameters of the influent and effluent exhibit significant differences ($p<0.05$), except for pH and temperature. There was no significant difference between the temperature values of treated and untreated wastewater which were recorded as 27.3±0.01 and 29.4±0.02 (°C). Wastewater typically has a neutral to slightly acidic pH (around 6-8). In this study, the mean pH values for treated and untreated wastewater were 7.14±0.02 and 7.25±0.03 respectively. The temperature of treated and untreated wastewater was generally similar although variation might occur due to the kind of heating and cooling processes employed in the treatment plant (11).

The mean value of the studied heavy metals (manganese, iron, and zinc) of the Wupa wastewater treatment plant shows a significant difference ($p<0.05$) between the treated and untreated wastewater as the effluent recorded low values after treatment. Manganese, iron, and zinc are commonly present in wastewater due to their occurrence in industrial discharges, stormwater runoff, and domestic sewage (18). Their presence in wastewater can significantly affect the performance of wastewater treatment plants and pose environmental risks if not properly managed. From the results obtained, the concentration of heavy metals is in the following order of decreasing magnitude Fe > Mn > Zn. The concentrations of Fe, Mn, and Zn were all above the safe limit of

Table 4: Fungi isolates wastewater influent and effluent of Wupa wastewater treatment plant Abuja.

Isolates	Influet	Effluet	Number of isolates	% Occurrence
Penicillium ascomycetes	+	-	1	9.09
Penicillium chrysogenum	+	+	2	18.18
Aspergillus terreus	+	+	2	18.18
Trichophyton rubrum	+	-	1	9.09
Trichophyton martegrophyta	+	-	1	9.09
Trichophyton megninii	+	+	2	18.08
Trichophyton tonsurars	-	+	1	9.09
Penicillium sp.	+	-	1	9.09

Table 5: Bioremediation Potentials of Indigenous Fungi isolates from Wupa WWTP, Abuja

Fungi Isolate	Growth observed after 7 days
Penicillium ascomycetes	++
Penicillium chrysogerum	++
Aspergillus terreus	+++
Trichophyton rubrum	+++

+++ Maxinium Growth; ++Moderate Growth; + Minimum Growth; - No Growth

Table 6: Bioremediation Potentials of Bacteria

Bacteria Isolates	Growth observed after 7 days	Mean ± SD absorbance
Stenotrophomonas sp.	+++	0.848 ± 0.19
Bacillus fusiformis	+++	0.704 ± 0.16
Stenotrophomonas maltophilia	+++	0.883 ± 0.31
Lysinibacillus sp.	+	0.285± 0.33
Enterococcus casseliflavus	+++	0.978 ± 0.30
Duganella Callida	+++	1.402 ± 0.01
Stenotrophomonas sp.	+++	0.848 ± 0.19
Bacillus fusiformis	+++	0.704 ± 0.16
Stenotrophomonas maltophilia	+++	0.883 ± 0.31

+++ Maxinium Growth; ++Moderate Growth; + Minimum Growth; - No Growth

WHO standards for effluent before discharge (19). The water treatment process was not sufficient in the reduction of heavy metals within WHO accepted limit of wastewater before discharge to the environment (19). The result shows a significant reduction of Iron (Fe) and manganese (Mn) and no reduction of Zinc (Zn) concentration in the effluent water as against the high concentration reported for the influent.

The mean value of manganese ranged from 0.31±0.10mg/L in the effluent to 0.37±0.20 mg/L in the influent in this study. Manganese mean value shows a significant difference ($p<0.05$) between the influent and effluent as the effluent records low values after treatment. The concentration of manganese in this study is in accordance with a study done in Ghana which reported a higher concentration of Mn in effluents; levels of Mn ranged from 0.2-4.2 mg/l (20). The presence of manganese in wastewater treatment plants can impact the treatment process as it may cause clogging and fouling of filters and membranes. In addition, manganese can promote the growth of certain microorganisms, leading to the formation of biofilms and reducing the efficiency of the treatment system (21). In cases where wastewater is not treated and discharged to the environment, high levels of manganese in water bodies have been known to cause oxidative stress and generally affect the soil structure (22).

The mean value of Iron ranged from 0.91±0.3mg/L in the effluent to 1.58±0.2mg/L in the influent. Iron mean value shows a significant difference ($p<0.05$) between the influent and effluent as the effluent records low values after treatment. The iron concentration of this study is in accordance with a similar study conducted in Uganda where they recorded Fe levels of 1.13 mg/l and 1.13 mg/l in effluents (23) while another study by Bahiru et al., (24) recorded a higher concentration of iron, 2.89±0.04, 3.62±0.04 and 5.13±0.06 mg/L, respectively. This study also showed the concentration of iron above WHO accepted limit for wastewater of 0.3 mg/l (19) for both influent and effluent. The presence of iron in these wastewater treatment plants could be a result of precipitation and sludge formation, which can lead to clogging and reduced efficiency of the treatment process. Moreover, iron can promote the growth of iron bacteria, which can cause corrosion and deterioration of infrastructure (25). In cases where wastewater has not been treated and discharged to the environment, the high iron content in water has been known to cause neuro-degenerative conditions and contributes to soil acidification leading to loss of phosphorous (20).

The mean value of Zinc ranged from 0.501±0.10mg/L in the influent to 0.501±0.10mg/L in the effluent. The zinc mean value shows a significant difference ($p<0.05$) between the influent and effluent as the effluent recorded low values after treatment. The concentration of zinc was lower, at a level of 0.18 mg/L in a similar study conducted by Ibrahim et al., 2023 at the Wupa wastewater treatment plant in Abuja. This could be due to the period of sample collection since Wupa WWTP receives diverse industrial and domestic wastewater from Abuja (10). The presence of zinc in this wastewater treatment could lead to toxicity for aquatic organisms and can also affect the biological treatment processes in wastewater treatment plants (26). Also, zinc has been linked to inhibiting the activity of microorganisms which are responsible for organic matter degradation, leading to reduced treatment efficiency (26). Zn is the least toxic and is an essential element in the human diet as it is required to maintain the proper functioning of the immune system, and normal brain activity and is fundamental in the growth and development of the foetus, but the very high concentration is very toxic, hence harmful to the human body (27).

Screening of Indigenous Wastewater Isolates for Bioremediation Potentials

The bacteria isolates encountered in this study are Stenotrophomonas sp. Bacillus fusiformis, Stenotrophomonas maltophilia, Lysinibacillus sp. Enterococcus casseliflavus, and Duganella callida. The fungi isolates are Penicillium ascomycetes, Penicillium chrysogenum, Aspergillus terreus, Trichophyton rubrum, Trichophyton martegrophyta, Trichophyton megninii, Trichophyton tonsurars and Penicillium sp. The presence of these groups of organisms in wastewater is of public health importance (28). It indicates their diverse metabolic capabilities and their potential applications in the bioremediation of contaminated water.

Aspergillus terreus recorded the highest mean absorbance with 0.904 ± 0.00. This absorbance recorded could be due to the ability of Aspergillus terreus to degrade various organic compounds, including polycyclic aromatic hydrocarbons (PAHs) and dyes (29). Trichophyton rubrum recorded an absorbance of 0.892 ± 0.11. This absorbance and growth rates observed could be due to the potential of T. rubrum to degrade the synthetic dye, Acid Orange 7 (AO7). Yan et al., (30) reported T. rubrum can produce the enzyme laccase, which is involved in the degradation of AO7, suggesting the potential use of T. rubrum in the bioremediation of dye-contaminated wastewater (31).

Penicillium ascomycetes recorded an absorbance of 0.577 ± 0.08 and Penicillium chrysogerum recorded the lowest absorbance of 0.473 ± 0.03 in this study. Penicillium is a widely distributed genus of fungi known for its diverse metabolic capabilities. Several species within the genus have been studied for their bioremediation potentials (32). Suriya et al., (33) also explored the ability of P. chrysogerum to degrade the pesticide chlorpyrifos. The bioremediation potential of the bacteria isolates revealed that Duganella callida had the highest absorbance with 1.402 which means was able to remove or clear up the heavy metals in the plates for its growth. The next was Enterococcus casseliflavus with 0.978, Stenotrophomonas maltophilia with 0.883, Stenotrophomonas sp. 0.848, Bacillus fusiformis 0.704 and the lowest was Lysinibacillus sp. with 0.285.

The presence of Stenotrophomonas sp. and Bacillus fusiformis in both effluent and influents of the Wupa wastewater treatment plant could be due to its ability to resist heavy metals and its potential to remediate heavy metals from contaminated water as it shows a range of 0.883 to 0.848 in this study. Stenotrophomonas maltophilia exhibited considerable resistance to heavy metals and has been used in the removal of heavy metals from contaminated environments (34). Chung et al., (34) reported that this bacterium can efficiently remove heavy metals, such as lead and cadmium, from contaminated environments. In this study, Bacillus fusiformis showed its potential in heavy metal bioremediation with absorbance of 0.704. This agrees with the work of Mustafa and Adebayo (35) who reported that this bacterium can bind and immobilize heavy metals, making it a promising candidate for bioremediation strategies.

Bacillus fusiformis showed potential in heavy metal bioremediation with absorbance of 0.704. The findings of this study agree with the study of Adebo, et al.,(36) where they recorded moderate growth and absorbance of Bacillus spp on heavy metals including zinc. Bacillus spp developed resistance due to exposure to toxic heavy metals shortly after the start of life in an already heavy metal-contaminated environment and also evolved metal resistance in response to exposure to heavy metal contamination (37).

Lysinibacillus sp. showed promise in heavy metal remediation with an absorbance rate of 0.285. This could be due to its ability to produce extracellular metabolites that can sequester metals. This finding is also in agreement with the work of Kumar et al., (15) who reported that Lysinibacillus sp. isolated from a mine tailing site was able to effectively remove heavy metals, including copper, zinc, and cadmium, from contaminated water. Enterococcus casseliflavus demonstrated potential in heavy metal bioremediation by recording an absorbance of 0.978. Joshi et al., (38) in their study also reported that this bacterium was able to efficiently remove chromium, copper, and zinc ions from contaminated water.

Duganella callida had a high absorbance of 1.402 which means was able to bioremediate or clear up the heavy metals in the tubes for its growth. The presence of Duganella Callida in both effluent and influent in this study could be due to the ability of the bacterium to tolerate and withstand heavy metals in comminated soil and water. Tiwari et al., (39) also reported that this bacterium can tolerate and remove heavy metals, such as cadmium and nickel, from contaminated soil and water.

CONCLUSION

An exhaustive assessment of the WWTP revealed crucial insights into its operational efficiency and environmental impact. Moreover, the investigation into microbial communities within the WWTP unveiled diverse microbial consortia with the potential for heavy metal remediation. Based on the findings of this study, it can be concluded that wastewater discharged from WWTP was poorly treated, as shown by the high concentration of heavy metals and physicochemical parameters detected in the treated water. The measured parameters were above the WHO limit for the discharge of wastewater into the environment.

RECOMMENDATION

1. Based on the findings of this study, it is therefore recommended that industries and governments should fully adopt the use of microorganisms for treating and bioremediation of toxic and heavy metals from wastewater coming from the industries and municipalities.
2. Wastewater analyses should be conducted before discharging wastewater into the environment.
3. Periodic assessment of aquatic ecosystems should be done in order to measure the impact of effluents discharged into the environment.

Authors' contributions

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