Open Journal of Engineering Science (OJES)
ISSN: 2734-2115
Article Details:
DOI: 10.52417/ojes.v3i2.454
Article Ref. No.: OJES0302003-437
Volume: 3; Issue: 2, Pages: 27–43 (2022)
Accepted Date: December 10th, 2020

Open Journals Nigeria (OJN)
Open Access | Bi-annual | Peer-reviewed
www.openjournalsnigeria.org.ng
editorial@openjournalsnigeria.org.ng

RESEARCH ARTICLE OJES0302003-437

IMPACT OF THE DISPOSAL AND UTILIZATION OF WUPA WASTEWATER TREATMENT PLANT SLUDGE ON THE ENVIRONMENT

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ABSTRACT

The complete management of waste arising from various human activities due to increasing urbanization and industrialization puts the environment in danger of pollution, as it translates to waste generation that must be treated and disposed of. Wupa Wastewater Treatment Plant with a design capacity of 131,000 m^3/day (dry weather inflow) was conceived to treat the domestic wastewater generated from the Federal Capital City of Abuja. The effects of sludge disposal and reuse on the environment were determined. Questionnaires were physically self-administered in printed copies to the staff of the Wupa treatment plant, Aviation farm staff, and residents of the Wupa community, sludge samples were taken from the disposal bed, and water samples were taken from the River and Dug wells closest to the disposal bed, and places of reuse for physiochemical analysis in a laboratory. The chemical parameters of the samples were statistically analysed and the results showed that turbidity presented a mean value of 8.60NTU, as well as a significate concentration of Nitrate 8.23mg/l, and cadmium (0.05mg/l). Test of variance shows a significant difference in the values of sulphate and Nitrate (0.028 and 0.03 respectively) compared with the World Health Organization guidelines for natural surface and groundwater. Findings showed that of the 547.2 tons of the sludge produced annually 90.28% is disposed at the plants' sludge bed, 9% is used for agriculture, and 0.8% is used by research institutions, meaning utilization is very minimal. Land applications and disposal are environmentally safe as chemical parameters are significantly below the FEPA guidelines, but there is a higher concentration of Nitrate that makes the sludge unsafe to discharge to water bodies or heavily applied to lands with high water Tables as it can cause nutrients leachate. Finally, the overall impact evaluation of disposal and utilization of the sludge has only about 12% negative impact in the immediate environment of disposal and use.

Keywords: *Sewage Sludge, Environmental impact, Groundwater quality, Disposal Route*

INTRODUCTION

The management of waste produced by various human activities has put the natural ecosystem in danger of pollution due to inappropriate treatment and disposal. Solid waste management is now a universal issue attracting global attention in both developed and developing countries (Ndububa and Oyije, 2019).

"Sewage sludge is a semisolid, or slurry residual material that is generated as a by-product of wastewater treatment processes". Wastewater is simply 'used water' from any or a combination of sources which includes: Domestic wastewater, waste released from industries and commercial activities, stormwater runoffs, etc. (Raghupatruni, 2020).

The Wupa Sewage Treatment Plant (WSTP) which uses the typical Sewage Treatment process is situated in Wupa, at the Idu layout of the Federal Capital Territory, Abuja, Nigeria. It is located west of Abuja at the lowest altitude in the Capital City and lies between latitude 70' 201'' and 90' 201''N and longitude 60' 451'' and 70' 391''E (Raghupatruni, 2020; Ansari, 2014) near the Wupa River as indicated in Figures 1 below. "The Wupa River is part of the Jabi River watershed in Abuja which serves as the receiving end of the treated wastewater from the plant" (Oluwadamisi *et al.,* 2019).

The plant has a design capacity to accommodate an Average Dry Weather Inflow of 5,500m^3 per hour and 131,000 m^3 per day to meet the requirements of 700,000PE (Population Equivalent) (GEHS 2014; Oluwadamisi *et al*., 2019). Presently, Wupa Sewage Treatment Plant operates below its designed capacity at about 20% and generating about 2tons of sludge daily from a daily average influent of 23,000m^3/day (GEHS, 2014).

Domestic wastewater which is the major source of wastewater for the Wupa treatment Plant comes from household activities while industrial wastewater which is the second highest source comes from various sectors of industry like food processing, paper, laundry, and the pharmaceuticals sector. Wastewaters are rich in both organic and inorganic compounds depending on the production sources, and when theses wastewater is released to a water body can lead to a rise in nutrients (eutrophication) and chemical composition (pollution) of such water bodies (Raghupatruni, 2020; Ansari, 2014). However, sludge from treatment wastewater still contains heavy metals that can be detrimental to the environment depending on the wastewater sources and level of treatment.

Sewage sludge could also be abundant waste biomass, as its production keeps increasing due to population growth, particularly in developing countries. The number of wastewater treatment plants in most developed countries is also on the increase because of industrialisation, so more sludge is being produced [Saminu *et al.* 2017; Ndububa, and Kawu, 2018). Effective management and handling of these generated sludge in an environmentally friendly way have become a matter of increasing importance globally, due to the potential health risks on the environment when not properly treated and disposed of. Importantly, sewage sludge may contain large amounts of organic components and nutrients; hence, resource recovery from such abundant biomass is necessary (Nnamdi, 2017; APHA, 2005).

The final destination of treated sewage sludge usually is the land. Dewatered /dried sludge can be incinerated, buried in sanitary landfills or used in agricultural lands to make use of its value as soil conditioner or plant fertilizers. Since most sludge contains toxic industrial chemicals (sludge from industrial waste), it is not advisable to spread sludge from such wastewater source on lands where crops are grown for human consumption (Saminu *et al*., 2017; Ndububa and Kawu 2018).

In places where a suitable site for a land disposal bed is not available, like most urban areas, sludge may be incinerated or carbonated. The incineration process completely evaporates the moisture and converts the organic solids into inert ash which reduces the volume for more economic disposal. But air control consideration like the use of air-cleaning devices is very important during incineration.

Dumping sludge in the ocean was a common and economic way of sludge disposal for many coastal cities, but it's more a viable and legal option because of its ability to harm human and aquatic lives. This is now prohibited in the United States of America and many coastal by legislatures (Ndububa and Kawu 2018).

Impact assessment (IA) is a structured process that is used when considering the effects of a proposed action on people and the environment, to mitigate (or, if possible, dispose of) the planned action (Saminu *et al*., 2017). The need for an impact assessment is derived from the necessity for environmental protection and conservation measures if properly carried out. The action does not only restrict the degradation of the environment but will serve as a tool for setting sustainable environmental policies (Saminu *et al*., 2017; Nnamdi Ikpeze, 2014). Impact assessment is applicable at all levels of human decision-making, from policy formulation to project execution. Environmental challenges that are related to the recycling of sludge on land include the risk of nutrient leaching, impacts on biodiversity, and greenhouse gas emissions. Methane and nitrous oxide, both potent greenhouse gases, are both produced after sludge and other bio-wastes are recycled into agricultural land (Tchobanoglous, *et al.* 2010). Sludge disposal could affect the environment as it could contain harmful components like pathogenic organisms, organic compounds, heavy metals, and excess phosphorus and Nitrogen. Depending on the method of disposal, these effects can be immediate **or** time-delayed and non-linear (Tchobanoglous, *et al*,. 2010).

One of the water qualities that can be affected by the disposal of sewage sludge is turbidity which is the cloudiness of water (Tchobanoglous *et al.,* 2010) and a measure of the ability of light to pass through water. It is affected by suspended materials; clay, silt, and organic material present in water (APHA, 2005). Another physical parameter is temperature. Taste, viscosity, solubility, odours, and some chemical reactions that take place in water are influenced by its temperature (Spellman, 2017).
The treatment process, time and biological oxygen demand (BOD) of water are also temperature dependent (Davis, 2010)**.** The process and speed of removal of heavy metals from wastewater during treatment is also temperature related (Hammer, 2011; Davis, and David, 2008).

The chemical parameters tested for include; pH, which is the negative logarithm of the hydrogen ion concentration (Viessman and Hammer, 2004; Edzwald, 2010) it is a dimensionless number indicating the acidic or basic strength or concentration of any water (Hammer, 2011).

Other chemical parameters include; sulfate ions ($SO42^{-}$) that can be affected by natural deposits of sodium sulfate (Glauber's salt) or magnesium sulfate (Epson salt) (Spellman, 2017; Abbas *et al.* , 2014], nitrogen in the form of organic and ammonia compounds transformed by microbes to form nitrites and nitrates (Abbas *et al.* 2014), Iron and manganese has the ability of causing bitter taste in water even with mild contamination (Larsen, 2017; US Environmental Protection Agency, 2010).

The Wupa Wastewater Treatment Plant has been in operation for over ten years and sludge is continuously generated without a deliberate study on the effect the sludge could have on the environment. Therefore, this study aimed to establish the physio-chemical composition of the sludge and the impact of its disposal and utilization on the environment.

MATERIALS AND METHODS

The Study Area

The study areas include the Wupa community situated within the Idu Layout located west of Abuja (Ndububa and Oyije, 2019; Raghupatruni, 2020), the Wupa River which is part of the Jabi River watershed and the aviation farm where sludge is majorly applied to the land for agriculture.

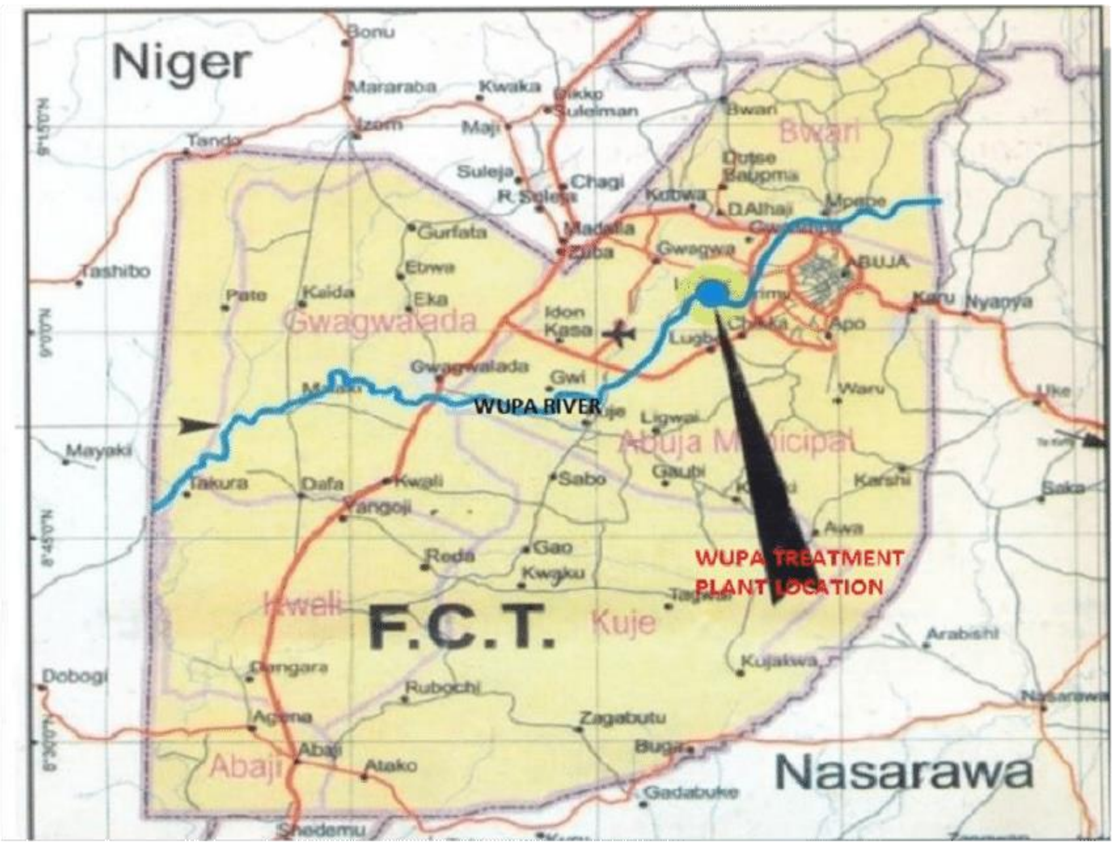

Figure 1: Map of Abuja, Nigeria showing the locations of the Wupa Treatment plant and Wupa River.

Data Collection and Analysis

Two sludge samples were taken from the disposal dry bed about 10m apart using a stainless steel trowel and a 500ml glass beakers, three water samples were taken from the Wupa river which is about 15m from the disposal bed with coordinates 321795.92, 997599.98, a point 5m to the effluent discharge point on the River with coordinate 321791.88, 997912.26 and a location upstream the river as control with coordinate 321762.41, 998238.09. From the aviation river three water samples were also taken; a point downstream the river 45.65m to the orchard-2 (a point close to the point of use) with coordinates 310395.34, 99381305.05, a second location with coordinates 310933.12, 994531.15 and a location upstream the river as control with coordinate 310938.82, 994509.95. From the closest community to the Wupa Treatment Plant (Dzhidu community, Wupa), three samples were also taken from three dug wells (measuring about 4-5m deep each) which serve as a source of domestic water to the host community. The temperatures were taken at the points of water collection before transporting to the Wupa Treatment Plant laboratory for the **physiochemical analysis**

Chemical parameters tasting.

Sampling was carried out by ensuring that: Sterilised Plastic sampling bottles were used for the water samples, The sample bottles were clearly labelled for easy identification, Care was taken to avoid accidental contamination of the samples during collection and subsequent handling before the analysis, lids were tightly placed on the sampling bottles, and the samples were all taken in the early hours of the day and, kept cool in an insulated container and driven in an air-conditioned car to the laboratory within two hours of collection.

Physiochemical Parameters

The mode of disposal of the sewage produced from the Wupa Treatment Plant was determined with the administration of questionnaires to the staff of the Wupa treatment plant and by physical visitation assessment to the treatment plant while the reporting and presentation were done with a Microsoft excel spreadsheet. Twenty (20) questionnaires in printed hard copies were physically administered to twenty out of the total twenty-seven staff of the Wupa wastewater Treat Plant and seventeen (17) were received filled. Seventeen (17) were administered to residents of the Wupa community; thirteen (13) were received while five (5) were administered at the Aviation Farm and the five received.

Water quality parameters (physical, chemical, and microbiological properties) that could be affected by sewage or wastewater contamination were tested for, and they include temperature, pH, electrical conductivity, turbidity, dissolved oxygen, nitrate, sulfate, zinc, iron, manganese, copper and cadmium.

The water samples were analyzed for properties like; pH values, Turbidity, Temperature, Electrical conductivity (EC), Dissolved Oxygen (DO), Nitrate ($No3^-$), Sulphate ($So4^-$), Iron (Fe^{2+}) copper (Cu^{2+}), Zinc (Zn^{2+}), lead (Pb^{2+}) and cadmium (Cd^{2+}). The multimeter system of measurement was used to determine the electrical conductivity, the oxygen meter and sensor were used to determine the dissolved oxygen while the spectrophotometer was used to determine the absorbance value of the water samples, and using the standard curve graph for the appropriate metal, the molarity (molar concentration) of the unknown solutions was determined by putting the absorbance on the y-axis and reading the molarity on the x-axis.

The Microsoft Excel spreadsheet and the Statistical Package for Social Sciences (SPSS Version 25) software were used for the data analysis and presentations.

RESULTS AND DISCUSSIONS

The results of the questionnaire administered in three different locations namely the Wupa Wastewater Treatment plant, Aviation Farm, and Wupa (Dzhidu) village are presented in Table 1, while the results of the laboratory analysis of the sludge and water samples are presented in Table 2.

Table 1: Questionnaire Results

S/N	Question	Respondent	Response	Number of respondents			Total
				Wupa WTP Staff	Aviation Village	Wupa village	
1	Mode of disposal of sludge	36	Dry bed only	3	0	5	8
			Dry bed+ farming	9	4	0	13
			Dry bed+farming +Research	4	0	9	13
			Don't know	1	1	0	2
2	Does the disposed or used sludge have offensive smell	36	No smell	13	5	14	32
			Offensive smell	0	0	0	0
			mild smell	3	0	0	3
3	Source of drinking/ domestic water for the residence	36	Dug well	4	0	2	6
			Dug well + borehole	8	5	7	20
			Dug well +	3	0	5	8
			Any others:	1	0	0	1
4	Has there be any reported case of water pollution linked to the sludge disposal	36	Yes	0	0	0	0
			No	17	5	14	36
5	Do people come to take this sludge for use? If yes what categories of people are they?	36	Farmers	12	5	3	20
			Gardener	-	-	2	2
			Government	2	0	0	2
			No ideal/ No answer	6	2	9	17
6	Has there be any case of negative environmental impact from any user of the sludge	36	Yes	0	0	0	0
			No	17	5	14	36
7	Has there be any complaint about water pollution due to the sludge application to land	36	Yes	0	0	1	1
			No	17	5	13	35
8	Has there be report of increase productivity due to sludge use for farming or gardening?	36	Yes	6	5	0	11
			No	4	0	4	8
			No response	6	0	10	16
9	Has there be a report of leaching or eutrophication of any surface water within the area of sludge use or disposal?	36	Yes	0	0	0	0
			No	12	5	6	23
			No response	5	0	8	13

Table 2: Laboratory Results of Physiochemical Analysis of Sludge and Water Samples

Parameters/ Samples	Units	Sludge		Wupa river			Aviation farm river			Dug wells		
		Sample-1	Sample-2	Sample-1	Sample-2	Sample-3	Sample-1	Sample-2	Sample-3	Well-1	Well-2	Well-3
Temperature	ºC	18.6	18.8	18.90	18.87	18.83	18.60	18.70	18.65	18.93	18.87	18.90
E.C	(µs/cm)	334	332	296.00	288.50	281	266	263	260	184.6	184.60	184.6
pH	moles / l	6.93	6.93	7.34	7.29	7.23	7.38	7.38	7.39	7.43	7.38	7.32
Turbidity	NTU	26.2	26.2	10.22	10.21	10.19	10.50	10.38	10.25	5.2	5.20	5.2
Disolved Oxygen	mg/l	5.74	5.54	7.10	7.10	7.09	6.88	6.95	7.02	8.28	9.82	8.24
Nitrate ($N03^-$)	mg/l	42.11	43.69	9.80	10.75	11.70	9.60	9.60	9.60	4.2	4.35	4.5
Sulphate ($S04^{2+}$)	mg/l	21.00	21.00	8.30	8.21	8.12	8.00	8.05	8.10	2.2	2.10	2.0
Iron (Fe^{2+})	mg/l	0.20	0.20	0.320	0.32	0.320	0.17	0.17	0.17	0.31	0.32	0.3
Copper (Cu^{2+})	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc (Zn^{2+})	mg/l	0.01	0.01	0.04	0.05	0.06	0.09	0.10	0.10	0.09	0.09	0.09
Lead (Pb^{2+})	mg/l	0.06	0.06	0.50	0.55	0.60	0.06	0.06	0.06	0.09	0.06	0.03
Cadmiun (Cd^{2+})	mg/l	0.39	0.33	0.11	0.11	0.11	0.02	0.02	0.02	0.012	0.01	0.011

Sewage Sludge Disposal Routes

From the questionnaire results summarised in Table 1, three lines of sludge disposal were identified namely: Dry bed disposal, agricultural use, and research institutions. The research, therefore, shows that other conventional disposal routes like sea dumping, landfill, and incineration are not used by the Wupa Waste Treatment Plant. Research showed that of the estimated 547.2 tons of sludge produced per year about 90.28% is disposed in the dry bed of the treatment plant while only about 9.77% is disposed of through other means.

The percentage of the Wupa sludge disposed of through the identified three routes is shown in Figure 2 below. It shows that the majority of the sludge; 90.28% is disposed of in the dry bed of the treatment plant, 9% is disposed of through agricultural land application, and 1% through research institutions. However, there is no sludge incineration, no landfill disposal, and no disposal to sea from the Plant.

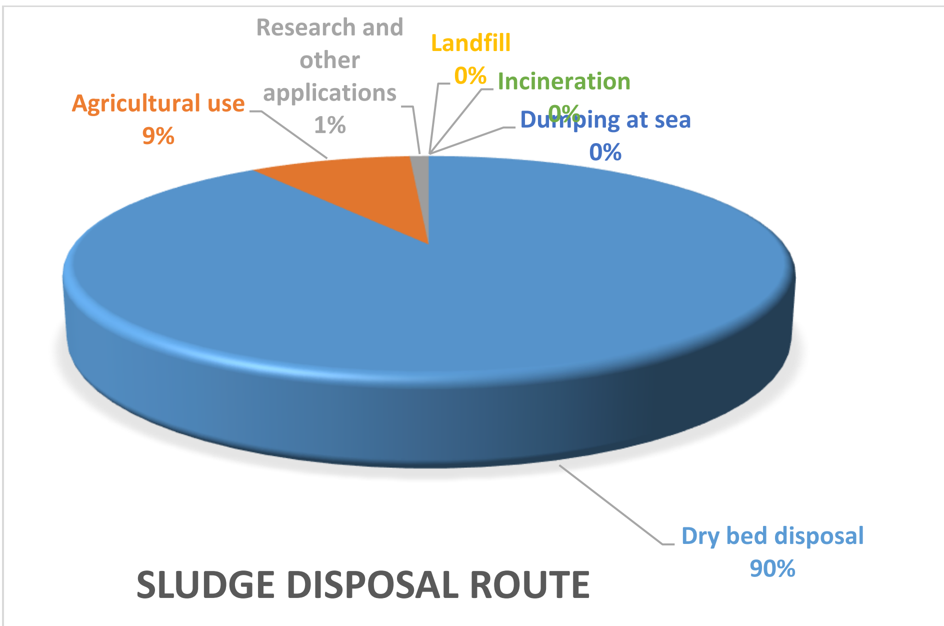

Figure 1: Wupa Sludge disposal routes in a pie chart presentation

Impact of Wupa Sewage Sludge on the Quality of Air

Table 1 shows the results of the questionnaire on the effects of sludge on the quality of air. Results show that there is no offensive odour within the treatment dry bed, the host village, and at the aviation farm as only 2.7% of the treatment plant staff, representing 1% of the total respondents say there is a mild smell when the sludge is freshly disposed of. This means there are no significant adverse effects on the quality of air.

Environmental suitability of Wupa Sludge disposal

The sludge was analyzed for some physicochemical properties as shown in Table 3 to compare with the National Effluent Limitation Guidelines of Nigeria to ascertain the level of environmental suitability for disposal, all parameters meet the FEPA guidelines for land applications and water discharge except for Nitrate ($N03^-$) which is higher than the required limit of 20.0mg/l for water discharge (Ndububa and Adamolekun, 2017; Oloruntade *et al.*, 2013).

The Nitrate concentration makes the sludge suitable for gardening and large-scale agricultural fields and not for discharge into water bodies; it enhances plant growth and provides a ready supply of nitrogen from which plants can draw (White *et al.*, 2017; FEPA, 1991).

Table 3: National Effluent Limitation Guidelines in Nigeria & Wupa Sludge average properties

Parameters	Units	Wupa Sludge	FEPA Guidelines	
			Surface water discharge	Land application
Temperature	ºC	18.7	<40	<40
E.C	(µs/cm)	333	N.A	N.A
pH	moles/ l	6.93	0-9	6-9
Turbidity	NTU	26.2	N.A	N.A
Dissolved Oxygen	mg/l	5.64	-	-
Nitrate ($N03^-$)	mg/l	42.90	20	-
Sulphate ($S04^{2+}$)	mg/l	21.00	600	1000
Iron (Fe^{2+})	mg/l	0.20	20	-
Copper (Cu^{2+})	mg/l	<0.1	<1	-
Zinc (Zn^{2+})	mg/l	0.01	<1	-
Lead (Pb^{2+})	mg/l	0.06	<1	-
Cadmiun (Cd^{2+})	mg/l	0.36	1.0	1.7

Samples Analysis for Possible Sludge Contamination

The mean values of the physiochemical parameters of all water samples from Wupa River, Aviation Farm River and Dug wells statistically presented in Table 5 show that pH has the highest standard deviation of 8.45 followed by Sulphate ($S04^{2+}$) 3.48 and Nitrate ($N03^-$) with 3.41. A high pH value is indicative of the alkalinity of the water sources which also shows that there is no contamination. However, the higher concentration of Iron (0.27mg/l) in the water samples compared to the sludge concentration (0.20mg/l) could be from other natural sources or human activities, which is still within the acceptable limits by WHO and FEPA for natural water sources.

Table 4: Mean values of physiochemical parameters

Parameters/ Samples	Units	Sludge sample	Wupa River	Aviation farm River	Dug wells
Temperature	ºC	18.7	18.87	18.63	18.92
Electrical conductivity (E.C)	(µs/cm)	333	288.50	263.00	184.60
pH	moles/ l	6.93	7.29	7.38	7.38
Turbidity	NTU	26.2	10.21	10.38	5.20
Dissolved Oxygen	mg/l	5.64	7.10	6.95	8.26
Nitrate ($N03^{-}$)	mg/l	42.90	10.75	9.60	4.35
Sulphate ($S04^{2+}$)	mg/l	21.00	8.21	8.05	2.10
Iron (Fe^{2+})	mg/l	0.20	0.32	0.17	0.31
Copper (Cu^{2+})	mg/l	<0.1	<0.1	<0.1	<0.1
Zinc (Zn^{2+})	mg/l	0.01	0.05	0.10	0.09
Lead (Pb^{2+})	mg/l	0.06	0.55	0.06	0.06
Cadmium (Cd^{2+})	mg/l	0.36	0.11	0.02	0.01

Source: Generated data 2022

The chemical variables from the three sample sources (Wupa River, Aviation Farm River and Dug wells from Wupa village) were statistically analysed as shown in Table 5, the result shows that turbidity has the highest mean value (8.60NTU) followed by Nitrate (8.23mg/l) whereas cadmium has the lowest mean value of (0.05mg/l). Moreover, sulphate has the highest standard deviation of (3.48mg/l) followed by Nitrate (3.41mg/l) whereas copper and Zinc have the lowest mean values of (0.00mg/l and 0.03mg/l) respectively.

Table 5: Descriptive statistics of water samples

Variables	units	Min.	Max.	Mean	Std. Deviation	Skewness	Sludge sample	F	Sig.
pH	mol/l	7.29	7.38	7.32	8.45	0.021	6.93	198.31	0.054
E.C	(µs/CM)	184.6	288.50	245.37	0.00	0.0	333	318.53	0.043
Turbidity	NTU	5.20	10.38	8.60	2.94	-1.73	26.2	247.05	0.048
Dissolved Oxygen	mg/l	6.95	8.26	7.44	0.72	1.65	5.64	247.01	0.048
Nitrate ($N03^{-}$)	mg/l	4.35	10.75	8.23	3.41	-1.51	42.90	733.05	0.028
Sulphate ($S04^{2+}$)	mg/l	2.10	8.21	6.12	3.48	-1.73	21.00	628.85	0.030
Iron (Fe^{2+})	mg/l	0.17	0.32	0.27	0.08	-1.70	0.20		
Copper (Cu^{2+})	mg/l	<0.10	<0.10	<0.10	0.00	0.00	<0.1		
Zinc (Zn^{2+})	mg/l	0.05	0.010	0.080	0.03	-1.46	0.01		
Lead (Pb^{2+})	mg/l	0.06	0.55	0.22	0.28	1.73	0.06		
Cadmium (Cd^{2+})	mg/l	0.01	0.11	0.05	0.06	1.67	0.36		

Source: SPSS Generated data, 2022

The parameters correlation in Table 6 shows how the variables are linearly related. A positive correlation indicates that the two variables are similarly correlated, i.e. their changes are in the same direction (increasing or decreasing). A correlation significance of the 0.05 level (2-tailed) was used to determine whether the correlation between variables is significant, comparing the p-value to the significance level.

Table 6: Pearson correlation of water and sludge samples physiochemical data

	NTU	DO	N03-	S042+	Fe2+	Cu2+	Zn2+	Cd2+	Pb2+
NTU	1								
DO	-0.99*	1							
N03-	0.98	- 0.96	1						
S042+	0.99*	- 0.99	0.99	1					
Fe2+	- 0.47	0.54	-0.29	- 0.43	1				
Cu2+	.b	.b	.b	.b	.b	1			
Zn2+	- 0.30	0.23	-0.48	- 0.35	- 0.70	.b	1		
Cd2+	0.55	-0.49	0.71	0.60	0.47	.b	-0.96	1	
Pb2+	0.47	- 0.41	0.64	0.52	0.55	.b	- 0.98	1.00	1

Source: SPSS Generated data, 2022

*.Correlation is considered significant at the 0.05 level (2-tailed).
b. shows situations that could not be computed as a result of two or more variables being constant.

Impact assessment on groundwater quality

The physiochemical parameters of all samples tested were also compared with the WHO guidelines for fresh, surface, and groundwater; Table 7, both rivers and wells meet the guidelines for natural water sources. Other researchers on analysis of access to improved water sources support obtained results (Ndububa and Adamolekun, 2017). On the other hand, comparing the same tested parameters with the WHO guidelines for drinking water shows that three parameters (turbidity, lead, and cadmium) exceed limits, meaning that these rivers and wells are not very suitable for drinking by WHO standards. However, the non-suitability of the water sources for drinking does not in any way suggest contamination from the sludge disposal or usage as most natural water sources are not suitable for drinking without treatment.

Table 7: Mean sample results with WHO guidelines

Parameters/ Samples	Units	Wupa River	Aviation Farm River	Dug wells	WHO Guidelines	
					Fresh/surface/ ground water	For drinking water
Temperature	ºC	18.87	18.63	18.92	<40	<40
Electrical conductivity (E.C)	(µs/cm)	288.50	263.00	184.60	1500.00	500.00
pH	moles/ l	7.29	7.38	7.38	6.5-8	ng
Turbidity	NTU	10.21	10.38	5.20	-	5.00
Dissolved Oxygen	mg/l	7.10	6.95	8.26	-	>6.5- 8.0
Nitrate ($N03^{-}$)	mg/l	10.75	9.60	4.35	50.00	10.00
Sulphate ($S04^{2+}$)	mg/l	8.21	8.05	2.10	250.00	250.00
Iron (Fe^{2+})	mg/l	0.32	0.17	0.31	50.00	0.30
Copper (Cu^{2+})	mg/l	<0.1	<0.1	<0.1	-	2.00
Zinc (Zn^{2+})	mg/l	0.05	0.10	0.09	-	3.00
Lead (Pb^{2+})	mg/l	0.55	0.06	0.06	-	0.01
Cadmium (Cd^{2+})	mg/l	0.11	0.02	0.01	1.00	0.00

Source: WHO Water quality for drinking water 2004

Table 8: One-way Analysis of Variance (ANOVA) with WHO guidelines for Fresh/surface/ ground water

Parameters		Sum of Squares	df	Mean Square	F	Sig.
Temperature	Between Groups	87126.65	5	17425.33	19.11	0.172
	Within Groups	911.65	1	911.65		
	Total	88038.29	6			
E.C.	Between Groups	71564.83	5	14312.97	318.53	0.043
	Within Groups	44.94	1	44.94		
	Total	71609.76	6			
PH	Between Groups	64206.15	5	12841.23	198.31	0.054
	Within Groups	64.75	1	64.75		
	Total	64270.90	6			
Turbidity	Between Groups	54923.05	5	10984.61	247.05	0.048
	Within Groups	44.462	1	44.46		
	Total	54967.51	6			
DO	Between Groups	54912.63	5	10982.53	247.01	0.048
	Within Groups	44.46	1	44.46		
	Total	54957.09	6			
Sulphate	Between Groups	27732.39	5	5546.48	628.85	0.030
	Within Groups	8.82	1	8.82		
	Total	27741.21	6			
Nitrate	Between Groups	27731.53	5	5546.31	733.05	0.028
	Within Groups	7.57	1	7.57		
	Total	27739.09	6			

Point of significant difference; Alpha (α) =0.05.

The test of variance for samples chemical parameters in Table 8 shows that Sulphate and Nitrate are significantly at variant with the WHO guidelines for Fresh/surface/ groundwater qualities with significance values of 0.030 and 0.028. But this is not suggestive of sludge contamination as both parameters are below WHO maximum limits. There was no significant difference the samples concentrations and the WHO guidelines.

Impact Evaluation

Impact evaluation was employed to assign quantitative significance to the predicted impacts associated with the sludge disposal and utilization using the Matrix Method. The mathematical weighting was based on the magnitude and significance of the potential impact of the sludge on the environment.

The magnitude is scored (in %) based on the result of the problems associated with the disposal route and the significance of impacts were weighted on a nominal scale of 0-0.5, and evaluated to be either positive or negative, denoting on whether the impact is beneficial or adverse, respectively.

The following magnitude of the disposal routes are as assigned below:

Treatment plant dry bed = 60%

Land applications (farming) = 35%

Other routes = 5%

The significance of the potential impacts was weighted as follows:

No significance = 0

Low significance = 0.1 or -0.1

Moderate significance = 0.2 or -0.2

High significance = 0.3 or -0.3

Very high significance = 0.4 or -0.4

The formula G= m* |Σs| (%) is used to determine the grand index of the impact each disposal route is likely to have on the indicative environmental component/ action, where;

G= Grad index expressed in percentage,

m= magnitude (%) attached to each disposal routes,

s= weighted significant values.

Table 9: Impact evaluation of the 3-disposal routes

Mode of disposal	Environmental concept					
	Air pollution	Water pollution	Leaching/ Eutrophication	Productivity	Research benefits	Grand index
Dry bed disposal	-0.1	0	-0.1	0	0	60 x -0.2= -12%
Land application	0	0	-0.1	0.3	0.1	35 x 0.3 =10.5%
Research/ Others	0	0	0	0	0.3	5 x 0.3 =1.5%
Totals	-1	0	-0.2	0.3	0.4	

Source: Generated data, 2022

From table 9 above, it is apparent that the Wupa Waste Treatment Plant sludge disposal has no significant negative (12%) possible impact on the environment and most of the impacts like odour only occur with freshly disposed sludge and within the dry bed area. Leaching/ eutrophication case has never been recorded but there is a possibility of occurrence due to high nitrate concentration of sludge.

Therefore, there is a need to ensure that sludge is not excessively applied to lands for agricultural use and on a continuous basis, especially to areas close to water bodies or land with high water table to avoid leaching/ eutrophication.

CONCLUSION

Based on the study, the following conclusions are made: a total of 547.2 tons of sludge is produced annually from which 90.28% is disposed at the plants' sludge bed, as the major disposal route. Study also showed that there is no adverse effect on the quality of air (no smell) within the treatment plant area, the host village, and at the Aviation farm as only 1% of the total respondents indicates there is mild smell when the sludge is freshly disposed.

The test of variance for chemical parameters shows that Sulphate and Nitrate are significantly at variant with the WHO guidelines for Fresh/surface/ groundwater qualities. This is not suggestive of sludge contamination as both parameters are below guidelines.

All analyzed parameters are significantly lower than the Federal Environmental Protection Agency (FEPA) guidelines for land discharge, making the sludge good for land discharge and applications. But by Federal Environmental Protection Agency (FEPA) Surface water discharge guidelines, there is a significant high concentration of Nitrate that makes the sludge unsafe to discharge into any water body or heavily applied to lands with high water table as it can lead to eutrophication or nutrients (Nitrate) leachate. From the general impact evaluation, disposal and utilization of the sludge has only about 12% negative impact on the environment, and this can be mitigated.

RECOMMENDATIONS

It is however recommended that A further study could be done on the amount of nitrate needed by plants to know if the Wupa sludge contains more than plants' need; as reviewed literatures shows that excess nitrate not used by plants, can leach through soil into groundwater.

Finally, a Periodic monitoring of water parameters of water bodies close to area of land application (especially the Aviation farm river, Abuja is recommended.

CONFLICT OF INTEREST

There is no conflict of interest in the course of this research and the manuscript presentation

ACKNOWLEDGEMENT

The Author acknowledge the University of Abuja and Wupa Waste Water Treatment Plant, Abuja

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