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Quality Assessment of Wastewater Released by Funtua Textile Limited, North Western Nigeria

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Abstract: *This research is focused on the assessment of the levels of physicochemical parameters and Water Quality Index (WQI) of wastewater samples collected from Funtua Textile and its environment using standard analytical methods. The results obtained were compared to those of the world health organization WHO (2011) recommended levels. Some of the analysed physicochemical parameters were carbonate ion (CO_3^{2-}), chloride ion (Cl^-), calcium ion (Ca^{2+}), nitrate ion (NO_3^-), total hardness (TH), colour and pH. The concentrations of CO_3^{2-}, Cl^-, TH, Ca^{2+} and NO_3^- were in the ranges of 317.7±5.6 (P10) to 498.0±1.6 (P1), 160.0±0.2) (P8) to 199.5± 0.6 (P1), 282.0±0.13 (P10) to 8837.9±0.2 (P7), 222.9±0.3 (P3) to 1518.2±0.00 (P1) and 44.1±0.3 (P9) to 57.9±0.30 mg/L, respectively. Those of pH and color were; 7.9±0.00 (P8 and P9) to 8.9±0.00 (P3) and 5.0±0.00 (P4, P7, P8, P9) to 60.0±0.0 0 (P1), respectively. Thus the concentrations of TH were found to be above the WHO (2011) permissible limit across the sampling points, while the levels of Cl^- and pH were found to be within the permissible limit set by WHO (2011). However, the levels of CO_3^{2-} and Ca^{2+} across the sampling points were above the recommended levels set by the Nigerian Industrial Standard (NIS, 2007). The levels of the physicochemical parameters analysed across the sampling points were in the following trend: P1>P3>P5>P4>P2> P6>P10>P7>P8>P9. The WQI recorded in this study was 61.58, this value falls into the poor category which is normally in the range of 51-75. Thus, the samples were found to be poor for use in both domestic and agricultural purposes unless subjected to further treatment. This is because, good quality water should be free from both chemical and biological contaminations, and must be acceptable in terms of color, taste and odour. Generally, P1 was found to be the most contaminated and P9 the least contaminated. The results reveal that there was no significant difference in the levels of the analysed physicochemical parameters at 95% (P< 0.05) confidence limit across the sampling sites. This clearly shows that the samples have a common pollution source.*

Keywords: *Wastewater, Funtua textile, WQI, physicochemical parameters, Nigeria*.

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1.0 Introduction

In recent times, most developing countries including Nigeria, have witnessed some levels of industrialization are therefore faced with the global challenge of waste management, especially between the point of production and disposal. An increase in population has also been acknowledged to be an enhancer towards the volume of wastes generated in our environment (Eddy *et al*., 2006). Some wastes can be useful for other purposes and some studies have shown that the application of resource recovery and recycling has been acknowledged for the management of some wastes (Eddy *et* al., 2022). The other classes of wastes have no immediate use to the environment and must therefore be systematically managed before they are disposed to the environment (Ahuti 2015). Several industrial wastes have been analysed and their toxicity has also been reported (Eddy and Garg, 2021). Such toxicity is attributed to the presence of poisonous substances such as dyes, heavy metals, organoleptic compounds, microorganisms and other physicochemical contaminants (Eddy and Ekop, 2007). In most cases, the most impacted component of the environment is the aquatic and terrestrial zones. The aquatic environment can be contaminated when industrial wastes (containing significant concentrations of contaminants) are discharged either directly or indirectly into the aquatic system (Uchechukwu *et* al., 2015). Cases of the applications of industrial wastewater (or other sources of water contaminated by industrial waste) in the irrigation of farmlands have been reported, especially in some rural areas where adequate water supply constitute a significant challenge (Chowdhary *et al*., 2020; EEA, 2018; Okereke *et al*. 2016). Such systems may constitute a secondary source of contaminants to man through the food chain. Consequently, continuous discharge of industrial wastewater into the environment may impact negatively global public health and food security (Omole, Isiorho, & Ndambuki, 2016). Therefore the present study aims to investigate the quality of wastewater generated by the Futual textile industries and its impact on food production in the surrounding and impacted soils.

The textile industry makes use of more than 8000 chemicals in various processes involving dyeing and printing Therefore, textile wastewater may contain some toxicants such as dyes, print pigments, hydrogen peroxide, starch, surfactants, dispersing agents and heavy metals (Bidu *et al.,* 2021). The alarming impacts of its composition are not favourable to man. For example, synthetic dyes and their transformation products could be carcinogenic and mutagenic, thus creating high risks to animal health (Zhou *et al*., 2019).

In Nigeria, environmental regulations on pollution control of industrial discharges and other pollutants are enforced by the Federal Environmental Protection Agency (FEPA) which relies on conventional physicochemical procedures. For the assessment of harmful health effects, it is essential to determine different chemical forms in wastewater (Betha *et al*., 2014; Sah *et al*., 2019). Physicochemical parameters of water are of high importance in the distribution of aquatic life and also in the breeding of aquatic life. They control chemical, biological and physical processes happening in the environment (Mohamaden *et al*., 2017). They also have a good influence on domestic life while physical and chemical parameters of soil and water affect many processes such as microbial activities, plant growth and mineral uptake by plants.

Water quality index (WQI) is a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water. It gives information on whether the overall quality of water bodies poses a potential threat to various uses of water, such as habitat for aquatic life, irrigation water for agriculture and livestock, etc. Rating of water in the aspect of quality and consumption using the effect of individual parameters can help environmental workers in decision making (Zahedi, 2017)..

2.0 Materials and Methods

2.1 The study area

The study area was the Funtua textile industry and its neighboring sites where irrigation is carried out. The industry was established in 1978 and is located between latitude 11°34’N and longitude $7^0$14’E in Funtua local government area of Katsina State, Northwestern Nigeria. Wastewater samples were collected at the point of effluent discharge inside the industrial zone while nine other samples were taken from the irrigation sites where the effluent from the textile industry is being used for irrigation farming.

2.2 Methods

Sample collection and pre-treatment: Samples of the wastewater analysis were collected in a 120 mL plastic container which was initially washed with detergent and then rinsed with distilled water. The sample containers were finally rinsed with 20% HNO_3 before sampling (Todorovi *et al*., 2001).

2.3 Measurement of physicochemical parameters

Water quality parameters such as color, nitrate and hydrogen ion concentration (pH) of the samples were determined using standard analytical methods. The pH, color and nitrate were determined using a portable HANNA, H19813-5 model, while calcium, chloride, carbonate and total hardness were verified according to APHA (2012) methods.

2.4 Statistical treatment of data

Microsoft spreadsheet was used to calculate the mean and standard deviation while SPSS software (version 20) was used to carry out the analysis of variance and person correlation test.

2.5 Quality assurance

All reagents used were of analytical grade, distilled de-ionized water was used. All the glassware and polythene sample bottles were washed with liquid soap, rinsed with distilled water, soaked in 10% HNO_3 for 24 h and rinsed thoroughly with distilled de-ionized water and thereafter dried (Todorovi *et al*., 2001).

3.0 Results and Discussion

Table 1 presents results of the physicochemical parameters of wastewater samples from the Funtua textile limited.

From the presented results, the mean concentrations of CO_3^{2-} , Cl^-, TH, Ca^{2+} and NO_3^- ranged from 317.7±5.6 (P10) to 498.0±1.6 (P1), 160.0±0.2) (P8) to 199.5± 0.6 (P1), 282.0±0.13 (P10) to 8837.9±0.2 (P7), 222.9±0.3 (P3) to 1518.2±0.00 (P1) and 44.1±0.3 (P9) to 57.9±0.30 mg/L, respectively. Also, the ranges for the pH and the color of the water samples were 7.9±0.00 (P8 and P9) to 8.9±0.00 (P3) and 5.0±0.00 (P4,P7,P8,P9) to 60.0±0.0 0 (P1), respectively.

The comparison of the levels of the analyzed physicochemical parameters with those of the World Health Organization (WHO, 2011) indicated that the concentrations of TH across the sampling points were above the WHO (2011) permissible limit. However, the concentrations of Cl^- and pH in the samples were within the respective 250 mg/L and 6.5-8.5 WHO (2011) tolerable limits. Concentrations of nitrates were observed to fluctuate across the sampling points such that concentrations higher than the 50 mg/L WHO (2011) tolerable limit were observed at sampling stations P1, P2, P3, P4 and P5. Similar trend was ocserved for color at the following sampling points, P1, P2, P3, P5 and P10 because the the concentrations recorded at these points were above the 15 HU required by WHO (2011). Mean concentrations of CO_3^{2-} and Ca^{2+} across the sampling points were also observed above the 150 mg/L recommended by the Nigeria Industrial Standard (NIS, 2007). Generally, measured physicochemical parameters were highest at P1 and least at P9. Variation of the physicochemical parameters in the different sampling stations assumed the following trend, P1>P3>P5>P4>P2>P6>P10>P7>P8>P9. Only sampling stations P7, P8 and P9 are higher than the control P10. This might be due to other source of pollution emanating from both agricultural and domestic sources.

The observed colour of the water samples from the various sampling locations is attributed to the dyeing process that leads to the discharge of large quantities of coloured effluent from the textile industry across the sampling points, this imparts some levels of coloration in the wastewater. The highest color level was found at point 1 (P1) which is the first point of effluent discharge from the industry. However, samples from points P1, P4, P8 and P9 showed the least colour intensity. The colour of the analysed water at various locations showed higher values compared to the ranges (5-20 and 5- 40 HU) reported by Joshi and Santani (2012) and by Patel *et al*. (2015) for water from some textile plants in India and Pakistan, respectively. However, the ranges reported for color in this study are lower than the ranges (272.8-487.05 and 17-140 HU) reported by Iram *et al*. (2013) and Bakar *et al*. (2020) for water samples from some textile industries in Pakistan and Malaysia, respectively. Color is an important physicochemical parameter, wastewater containing dyed effluents is hazardous to the aquatic ecosystem because it reduces the intensity of sunlight penetrating the water and hence, the rate of photosynthesis (Odoemelam *et al*., 2018). Consequently, several processes would be hindered including photochemical degradation of waste, absence of phytoplanktons, and associated impact on the aquatic organism, among others (Datta *et al*., 2009) .

The mean concentration of CO_3^{2-} in the wastewater samples for all the sampling stations were within the range, 317.7 - 498.0 mg/L. Sampling station P1, which is located at the point of the textile effluent discharge had the highest mean concentration of CO_3^{2-}, that is 498.0 mg/L. The source of the CO_3^{2-} in the wastewater may be linked to the dissolution of CO_2. CO_2 fluxes across the air-water or sediment-water interface are among the most important concerns in global change studies and are often a measure of the net ecosystem production/metabolism of the aquatic system (Patel *et al*., 2015).

Table 1: Physico-chemical parameters of wastewater collected from Funtua Textile Limited

Station	Colour (HU)	CO_3^{2-} (mg/L)	Cl^- (mg/L)	TH (mg/L)	Ca^{2+} (mg/L)	NO_3^- (mg/L)	pH
P1	60.0±0.0	498.0±1.6	199.5±0.6	6363.9±0.3	1518.2±0.0	50.7±0.2	8.0±0.0
P2	20.0±0.0	375.3±4.1	179.9±0.4	5252.4±0.1	344.2±0.2	51.7±0.2	8.3±0.0
P3	20.0±0.0	396.7±2.5	179.9±0.0	4848.2±0.3	485.9±0.3	51.8±0.2	8.9±0.0
P4	5.0±0.0	420.7±2.5	179.9±0.3	959.7± 0.2	425.1±0.0	53.9±0.1	8.7±0.0
P5	20.00±0.0	384.0±4.3	199.3±0.6	2020.1±0.3	484.9±0.2	57.9±0.3	8.5±0.0
P6	15.0±0.0	361.3±1.9	199.3±0.5	1767.9±0.3	303.6±0.1	46.8±0.2	8.3±0.0
P7	5.0±0.0	441.3±3.4	189.6±0.5	8837.9±0.2	222.9±0.3	46.4±0.1	8.2±0.0
P8	5.0±0.0	379.3±0.9	160.0±0.2	1010.1±0.0	282.9±0.3	47.9±0.1	7.9±0.0
P9	5.0±0.0	380.3±0.5	190.0±0.3	2019.9±0.2	323.7±0.1	44.1±0.3	7.9±0.0
P10	20.0±0.00	317.7±5.6	169.7±0.18	282.9±0.13	262.9±0.3	44.7±0.3	8.1±0.0
WHO	15		250	200		50	8.5

The range obtained for the concentration range of CO_3^{2-} in this study is higher than the concentration range of 120-330 mg/L reported by Patel *et al*. (2015) but lower than the ranges of 402 – 667 mg/L and 326 - 502 mg/L reported by Lokhande *et al.* (2011) and Tafesse *et al*., (2015), respectively. It was reported by Patil *et al*. (2012) that whenever pH reaches 8.3, the presence of CO_3^{2-} is indicative, but below pH of 8.3, the CO_3^{2-} is converted into an equivalent amount of bicarbonate. The presence of CO_3^{2-} ion in the water indicates alkalinity.

Furthermore, the concentration range recorded for Cl^- in this study was higher than the range of 98 - 103 mg/L reported by Qureshimatva *et al.* (2015) for textile effluent in India but lower than the ranges of 219-669, 127-396, 6-1180, 180-289 and 63-733 mg/L reported by Ahmed *et al*. (2012), Iram *et al*. (2013), Shroff *et al*. (2015), Patel *et al.* (2015) and Aniyikaiye *et al*. (2019), respectively. The possible source of Cl^- in wastewater is through the use of chlorinated compounds such as pesticides and those containing HCl, HClO, chlorine gas, which are typical raw materials in various dyeing processes. High Cl^- in wastewater disposed to the environment is responsible for leave margins, scorching and may lead to smaller and thicker leaves and reducing overall plant growth (Nadeem *et al*., 2018). Chloride in drinking water is generally not harmful to human health but when present in high concentrations, it can impart a salty taste to the water. At high concentrations, chloride may be injurious to heart and kidney patients. The restriction on chloride concentrations in potable water is determined by taste requirements (Manikandan *et al*., 2015). Excessive chloride in water may also lead to eye/nose irritation, stomach discomfort and increased corrosive properties of water and needs to be monitored in all cases (Cheremisinoff, 2001).

The concentration ranges recorded for the TH in the analysed wastewater was found to be higher than the ranges of 74–281, 321-420 and 300-452 mg/L reported by Rokade and Ganeshwade (2005); Ahmed *et al*. (2012) and Iram *et al*. (2013), respectively. However, the concentration ranges of 70-1040 and 1280-3885 mg/L (which are higher than the range we obtained) were reported by Scroff *et al*. (2015) and Manikanden *et al.* (2015). Total hardness observed in the analyzed wastewater samples was above the WHO (2011) permissible limit of 200 mg/L, especially for wastewater from sampling stations P1 to P10. This indicates the presence of Ca^{2+} and Mg^{2+} at high concentrations across the sampling points leading to water hardness on interaction with CO_3^{2-} The hardness of water is typical for calcium-enriched water and can initiate non potability of the water, in addition to other effects such as the poor formation of foam with soap, etc.

The mean concentration of Ca^{2+} in the analysed wastewater samples range from 222.86–1518.18 mg/L, the wastewater samples from the effluent discharge point had the highest concentration of 1518.2 mg/L. The concentration range of the Ca^{2+} was higher than the ranges of 16-98 and 31-93 mg/L reported by Kumar & Dua (2009) and Ihesinachi (2018). However, Iram *et al*. (2013) reported a higher concentration range of 139-7439 mg/L, this variation might be attributed to the time of the season when the samples were collected and the difference in the raw materials for the different industries (Rosborg & Kozisek., 2016).

The levels of NO_3^- at sampling points P1, P2, P3, P4 and P5 were above the WHO (2011) permissible limit of 50mg/L. They were also higher than the concentration ranges of 0.192 – 5.12, 6-8 and 13.-33 mg/L reported by Rokade and Ganeshwade (2005); Qureshimatva *et al.* (2015) and Ihesinachi (2018). Aniyikaiye *et al*. (2019) also reported a higher concentration range of 12-211 mg/L. The observed variation may be attributed to a different source of NO_3^- to the wastewater sample. High NO_3^- concentration may originate from the transfer of leached fertilizer's nitrate through surface runoff, erosion of natural deposits and chemicals used during desizing and dyeing processes (Lapworth *et al*., 2017). According to Patil *et al.* (2012), even low concentrations of NO_3^- can cause health problems to infants within the age of six months or less and to pregnant women by affecting the oxygen-carrying capacity of the blood which results in shortness of breath and blue baby eye syndrome (Patil *et al*., 2012).

pH is also a significant parameter needed for the assessment of the potability of water. The mean pH for the samples collected at various sampling points ranged from 7.9-8.7, the pH values 8.9 and 8.7 at points P3 and P4 were above the WHO (2011). The pH range reported in this study was also higher than the ranges of 6.3- 7.0, 6.4-8.0 and 6.9-7.1 reported by Tauqueer *et al*. (2020); Shroff *et al*. (2015) and Qadir & Chhipa, (2015) but lower than the ranges of 8-9, 9-11 and 4-12 reported by Patel *et al*. (2008); Imtiazuddin *et al.* (2012) and Aniyikaiye *et al*. (2019), respectively.

Table 2: Water quality index of analyzed water samples

Parameters	Observed Value	Standard Value (Sn)	1/Sn	∑1/Sn	K= 1÷∑1/Sn	Unit weight (Wn)= K/Sn	Quality rating (Qn)	Wn×Qn
Colour (HU)	17.5	15.00	0.667	0.821	1.22	0.081	116.66	9.45
CO_3^{2-} (mg/L)	395.47	-						
Cl^-(mg/L)	184.72	250.00	0.004	0.821	1.22	0.005	73.86	0.37
Total hardness (mg/L)	3336.3	200.00	0.005	0.821	1.22	0.006	1668.15	10.01
Ca^{2+} (mg/L)	465.45	-						
NO_3^- (Mg/L)	49.61	50.00	0.02	0.821	1.22	0.024	99.22	2.38
pH	8.29	6.5-9.5	0.125	0.821	1.22	0.144	0.86	0.12384

The alkaline nature of the analysed samples might be attributed to the use of bleaching agents and chemicals such as NaOH, NaOCl, sodium phosphate and surfactants during the dyeing and printing processes. Wastewater from other textile and dye industries as reported by Gowrisankar *et al*. (1997) and Tafesse *et al*. (2015) showed similar pH ranges of 7- 9. The reduced rate of photosynthetic activity, the assimilation of carbon dioxide and bicarbonates are some of the impacts associated with abnormally high pH. Abnormal levels of pH may also alter the concentrations of other substances in the water to a more toxic form (Patil *et al*., 2012). For instance, ammonia toxicity, chlorine disinfection efficiency, and metal solubility are all subject to changes due to pH value.

3.1 Water quality index (WQI)

The WQI calculated in this study was found to be 85.46 as could be observed in Table 2, this value falls into the very poor category which is normally in the range of 76-100 as reported by Brown *et al*. (1972). The result for the WQI in this study conformed with the range of 76-100 reported by Goi (2020) in a similar study conducted in India. Conversely, the WQI recorded in this study were lower than the range of values reported by Garba *et al*. (2021) in a similar study conducted in Bauchi metropolis, Nigeria. A comparison of the WQI with the expected ranges reported by Brown *et al*. (1972), suggests that the water is very poor in quality.

3.2 Statistical treatment of data

The application of ANOVA to the physicochemical parameters of the wastewater indicated that there was a significant difference at $P \leq 0.05$ (at 95% confidence limit) across the sampling point without an exception as reflected in Table 3. Therefore, the water samples across the sampling points have different pollution sources. Strong positive correlations were however observed between some of the physicochemical parameters such as $CO_3^{2-}1$ vs $CO_3^{2-}3$ and $CO_3^{2-}2$ across the sampling points and therefore suggest a common pollution source.

Table 3 Analysis of variance for the physicochemical parameters of the wastewater sample

ANOVA

Parameters		Sum of Squares	Df	Mean Square	F	P-Value
CO_3^{2-}	Between Groups	64492.133	9	7165.793	488.577	0.000
	Within Groups	293.333	20	14.667		
	Total	64785.467	29			
Cl^-	Between Groups	4803.985	9	533.776	2204.532	0.000
	Within Groups	4.843	20	.242		
	Total	**4808.827**	**29**			
TH	Between Groups	215095491.629	9	23899499.070	305698376.437	0.000
	Within Groups	1.564	20	.078		
	Total	**215095493.193**	**29**			
Ca^{2+}	Between Groups	3929707.417	9	436634.157	6815309.429	0.000
	Within Groups	1.281	20	.064		
	Total	**3929708.698**	**29**			
$N0_3^-$	Between Groups	526.781	9	58.531	997.692	0.000
	Within Groups	1.173	20	.059		
	Total	**527.955**	**29**			
pH	Between Groups	2.831	9	.315	1292.543	0.000
	Within Groups	.005	20	.000		
	Total	**2.836**	**29**			

Similar observations have also been reported for wastewater parameters by Adegbe *et al*., (2009); Navneet *et al*., (2010) and Yahaya *et al*., (2016) in Nigeria, Pakistan and India, respectively.

4.0 Conclusion

The elevated levels of these physicochemical parameters observed in the analysed samples could ultimately contaminate the cultivated crops, animals and thus making them toxic for human consumption. The Water Quality Index (WQI) of 85.46 recorded reveals that the water is very poor for both domestic and agricultural activities. It is therefore recommended that the water quality of the textile industry should be continuously monitored to assess the level of pollution.

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