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Physico-Chemical Characterization of Dry-Weather-Flow Wastewater and Assessment of Treatment Plants in Nitte and Environs, India

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Abstract
The effective treatment of a given wastewater depends largely on its characteristics. Physico-chemical parameters constitute indispensible analytes in wastewater. In two pre-monsoon months when there was Dry-Weather-Flow (DWF), this study characterized the wastewater in Nitte, India based on the physical and chemical properties. It also assessed efficiency of its domestic and industrial Wastewater Treatment Plants. Fourteen samples were collected from domestic and industrial wastewater in the environment, sources of which include:hostels, laundry, mechanical and auto-workshop effluent, foundry, WTP influent, and landfill leachates. Parameters measured are: colour, odour, temperature, turbidity, pH, electrical conductivity, chloride, nitrate, sulphate, phosphate, Chemical Oxygen Demand, Copper, Lead, Magnesium, Chromium, Nickel, Zinc, Manganese, Cadmium and Phenols, using Standard Methods. Findings show that the main physico-chemical parameters that are of pollution concern in the domestic wastewater of the study area include conductivity, chloride, COD, phenols, phosphate, Cu, Pb and Mg. Pollutants in the industrial wastewater encompass Cr and Zn in addition to those of domestic wastewater, while Cd is a key pollutant in leachates aside those identified in domestic and industrial wastewater samples. Domestic WTP is more suitable in remediating turbidity, sulphate, nitrate and phosphate unlike industrial one that is more efficient in treating chloride, Ni and Zn. Both reduced COD, with domestic WTP being of better performance but also not to a pollution-free concentration level. Both WTPs are found to be incapable of treating phenols in the samples.Further treatment methods like bioremediation, ion-exchange and adsorption are therefore recommended in addition to the existing WTPs in the study area.
Keywords: Pollution, Remediation, Trace metals, Wastewater, Concentration, Pollution,

1. Introduction

Sewage includes sullage, discharge from toilets, urinals, industrial effluents, surface and storm waters with a complex mixture of natural organic and inorganic materials and a small proportion of man-made substances, all carried through liquid media (Alade and Ojoawo, 2009; Punmia *et al.,* 2012). Municipal sewage is basically either domestic (sanitary) or industrial (trade). Domestic wastewater is obtainable from the lavatory basins, urinals, and water closets of residential buildings, offices, theatres, and other institutions. Its main constituent is human excreta and urine that are foul in nature. Industrial wastewater on the other hand is effluents from industrial and commercial establishments like those of textile, tannery, foundry, laundry, and brewery and so on. Between 70 – to 80% of fresh water supplied to a given community ends up as wastewater (Fair *et al.,* 1970).

Fresh water resources are becoming deteriorate day-by-day at the very faster rate thereby making the attainment of a good water quality a global problem (Mahananda *et al.,* 2005). The healthy aquatic ecosystem is depended on the biological diversity and physico-chemical characteristics of the water (Venkatesharaju *et al.,* 2010). Growing volumes of industrial and municipal sewage are being discharged at surface waters. Treatment provided is frequently inadequate to protect the desired uses of the receiving waters. Limited institutional capacity and financial resources make for difficult choices as governments try to optimize their investments in municipal systems and establish practical requirements for industrial / municipal sewage treatment (Joel *et al.,* 2009).

In determining the design parameters and sections of sewer, the quantity of wastewater to be conveyed is a key factor. Total wastewater comprises of 2 components viz: the Dry Weather Flow (DWF) and the Storm Water Flow (SWF). DWF is the flow through the sewers that would be available during non-rainfall periods. It therefore consists mainly of domestic sewage and industrial wastewater. SWF is the additional flow that would occur during the raining season that encompasses runoffs from roof, streets, open yards, open spaces etc (Punmia *et al.,* 2012). The key characteristics of wastewater generally includes the physical (colour, odour, turbidity, total solids, and tempearature); chemical (pH, chlorides, nitrates, phosphates, BOD, COD, alkalinity, phenols, surfactants, sulphates, heavy metals, fats, oils and greases, pesticides, etc); gases (hydrogen sulphide, methane, oxygen); and bacteriological (animals, plants, protista, viruses, etc).

The characteristics of sewage largely determine its pollution levels. Most heavy metals have detrimental effects on human and environment in different ways. For example lead in the environment is mainly particulate bound with relatively low mobility and bioavailability. Lead does, in general, not bioaccumulate and there is no increase in concentration of the metal in food chains. Lead is not essential for plant or animal life (European Commission, 2002; Karvelas et al., 2003; Duffus, 2002).

This paper examines the physico-chemical constituents of both the domestic and industrial wastewater being generated in Nitte community, India with a view to characterizing them; determining their pollution levels by comparing them with the effluent standards, and making appropriate recommendations on the treatment methods. Furthermore it assesses both the domestic and industrial wastewater treatment plants in the study area.

2. Materials and Method

2.1 The study area

Nitte, the study area, of Karkal Taluk in the Udupi District of Karnataka State, India, is located on latitude 13.1815 ^{0}N and longitude 74.9354 ^{0}E (IndiaMapped, 2014). Annually, the area witnesses two clear cut seasons: the pre-monsoon/dry (November to April) and monsoon/wet (May to October). The village is with a total population of 11,381 people and plays host to the NMAM Institute of Technology, NMAMIT, popularly called Nitte Engineering College, among other Institutions. A notable industrial wastewater source in Nitte and environs is a foundry cited about 5kms away along the Belman – Karkala road. Other sources of wastewater in and around the vicinity of the community aside the domestic ones include commercial laundries, auto-service workshops, waste dumpsites generating leachate, and the likes. The water demand of Nitte community is estimated to be 100 lpcd (Shridhara *et al.,* 2014), thus generating about 910,480 litres of wastewater per day, assuming 80% of water supply ends up as sewage (Fair et al., 1970). Two wastewater treatment plants (WTPs) are identified in the study area: the domestic one of NMAMIT and the industrial one of the foundry. The chambers for unit operations in the domestic WTP include Screening, equalization tank, aeration tank, settling tank, sludge drying bed, collecting water tank, chlorination and pressure filter unit, treated water tank, reed bed, and the polished water tank. The flowchart of these operations is as shown in Figure 1. The foundry WTP is however a compact system that mainly comprises of the screening, aeration, sedimentation, chlorination and pressure filter and the treated effluent units.

2.1 Sampling

The sampling exercise was carried out once in each of the pre-monsoon months of March and April, 2014. On each occasion, fourteen wastewater samples were taken from some selected sources that include both domestic and industrial. Sampling was done in line with the Standard Method (APHA, 2005). Table 1 gives detail on the representation of samples and their sources. As observed from the Table, the samples include: wastewater from residential hostels, raw and treated ones of domestic WTP, mechanical and auto-service station, commercial laundry, raw and treated effluents of the foundry WTP, and leachates

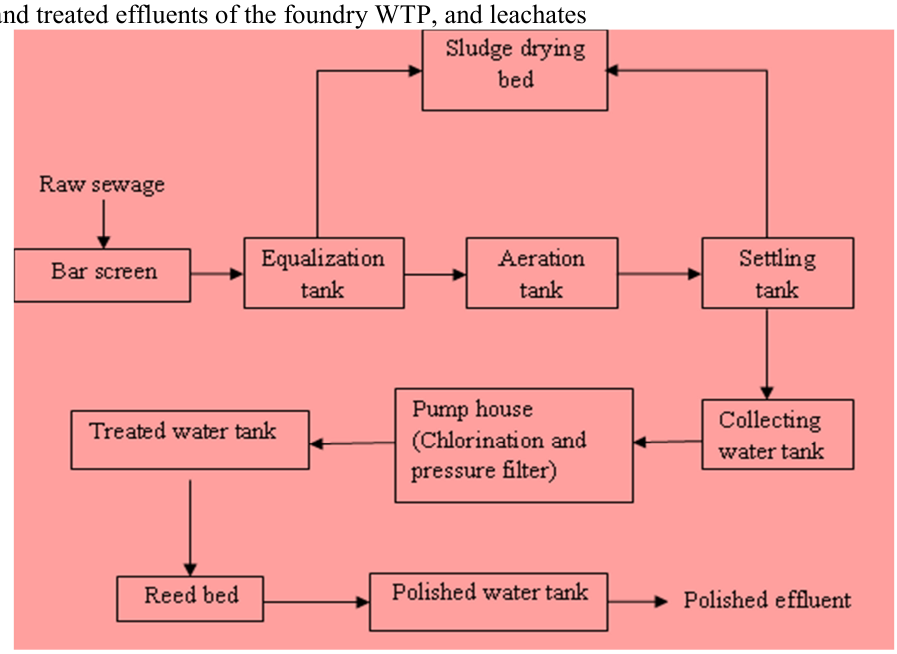

Fig. 1: Flow chart of Sewage Treatment Plant at NMAMIT Campus
Source: NMAMIT Resident Engineer's Records, 2014

Table 1: Representation of the wastewater samples

S/N	*Sample Label*	*Wastewater Sample Description*
1	BHN	Boy's Hostel, NMAMIT
2	PGGHN	PG Girl's Hostel, NMAMIT
3	GHKN	Girl's Hostel Kitchen, NMAMIT
4	WTPIN	Wastewater Treatment Plant Inlet, NMAMIT
5	WTPASN	Wastewater Treatment Plant Aerated Sample, NMAMIT
6	WTPFEN	Wastewater Treatment Plant Final Effluent, NMAMIT
7	MWKSN	Mechanical Workshop Septic Tank, NMAMIT
8	AUTOWWN	Auto-Service Wastewater, Nitte
9	CMLN	Commercial Laundry, Nitte
10	FRIN	Foundry Raw Inlet Wastewater, Nitte
11	FSSEN	Foundry Settled Sewage Effluent, Nitte
12	FFEN	Foundry Final Effluent, Nitte
13	WDFLV	Waste Dumpsite Fresh Leachate, Vamanjoor
14	WDSLV	Waste Dumpsite Stale Leachate, Vamanjoor

from aged waste dump sites. These were collected into 2-litre plastic bottles, corked and immediately transferred from the various collection points to the Laboratory for analysis.

2.2 Laboratory Analysis

Analyses of the samples were all carried out at both the Environmental Engineering and the Biotechnology Instrumentation Laboratories of the NMAMIT using Standard Method (APHA, 2005). The 19 measured physico-chemical characteristics include: colour, odour, temperature, turbidity, pH, electrical conductivity, chloride, phosphate, sulphate, nitrate, phenol and COD. The rest tested parameters are Cu, Pb, Mg, Cr, Ni, Zn, Mn and Cd. Visual and physical observations were made on the colour and the odour of the samples. Electrochemical measurements of the pH and temperature were carried out simultaneously on same digital Systronics µpH meter, System 361 model. Digital Systronic Nephelo-turbidity meter, System 132 model was engaged in determining the turbidity level of all samples. Electrical conductivity was also measured electrochemically using digital Systronic µSiemens conductivity meter, System 306 model that functions under room temperature.

Chloride concentrations/levels in the samples were determined using Argentometric titration method with Standard $AgNO_3$ solution (0.0141N). Standard sulphate solution was allowed to react with $BaCl_2$ in an active acid medium thereby precipitating sulphate ions and the absorbance of the solution measured with Systronics Spectrophotometer169 (λ = 420nm) equipment. Phosphate was estimated by the Fiske and Subbarow's method. Inorganic phosphate reacts with ammonium molybdate under acidic condition to form phosphomolybdic acid. Addition of reducing agent 1,2,4-aminonaphthosulphonic acid (ANSA) reduces the molybdenum in the phosphomolybdate to give a blue coloured complex, the intensity of which is proportional to the amount of phosphate present. The OD values (λ = 660nm) of both the Standards and concordant samples were read from Photochem 0-18 Colorimeter. A calibration curve was prepared with the Standards from where the unknown phosphate concentrations were determined.

Nitrate determination too was by spectrophotometry, using phenol disulphonic acid (PDA) method in which nitrate reacted with PDA and produced a nitro-derivative which in alkaline medium developed a yellow colouration. The spectrophotometer measured the nitrate absorbance at λ = 410nm. To estimate the phenol, colorimetric 4-aminoantipyrine method was used. The method is based on the formulation of antipyrene dye with phenolic compounds in the presence of alkaline oxidizing agent like potassium ferricyanide at pH 10.2. The color developed was read from Photochem 0-18 Colorimeter at λ = 530nm. COD measurement was through oxidation and reflux of samples with a known amount of potassium dichromate ($K_2Cr_2O_7$) in the presence of Sulphuric acid (H_2SO_4) by digestion, using Spectroquant TR420 COD Digester. The unreduced chromate ions are then subjected to titrimetry with 0.025M Ferrous

Ammonium Sulphate, FAS solution, using ferroin as indicator. The amount of dichromate consumed by the sample is equivalent to the amount of O_2 required to oxidize the organic matter in the sample.

The contents of Cu, Pb, Mg, Cr and the other trace metals in the samples were determined with the use of Flame Atomic Absorption Spectrometer (FAAS). Air-acetylene was the flame used in the analysis. The temperature formed in the air-acetylene flame was around 2300°C. In the FAAS technique, the neutral or ground state atoms of an element absorbs electromagnetic radiation over a series of very narrow, sharply defined wavelengths. The sample in form of a solution was aspirated as a fine mist into a flame at a point when it is converted to atomic vapour (Ojoawo and Udayakumar, 2014). These atoms in their ground states therefore absorb radiation of suitable wavelengths which has been supplied by the matching hollow cathode lamp of the element/metal being detected.

3. Results and discussion
The mean values of the laboratory results for the measured physico-chemical parameters in the samples are presented in Tables 2 – 4. A comparison is made on same Tables with the Effluent Standards provided by the Environmental Protection Agency (EPA) and the Indian Central Pollution Control Board (EPA, 2010; CPCB, 1998). Histograms representing the chemical characteristics and trace metals concentrations of the samples are shown in Figs. 2 to 4. The treatment removal percentages from the 2 WTPs are as indicated on Tables 5 and 6.

3.1 Physical parameters
The domestic wastewaters from student's hostel vary from murky yellow to pinkish orange and to light brown colour as shown on Table 2. The colour of auto-service and workshop sewage is dark-black, perhaps due to the pollution by the lubricating oils. Foundry wastewater is slightly dark while the fresh leachate sample is dark green and stale one dark brown. The treated effluents from the domestic and industrial WTP are clear in colour. Most of the samples have irritating odour: kitchen wastewater has sharp pungent odour, laundry has repelling while the stale leachate possesses pungent and irritating odour. The temperature of all the samples ranged between 29.0 and 31.6 ^{0}C. Kitchen wastewater and fresh leachate are observed to be the most turbid with 800 and 660 NTU respectively. NMAMIT's WTP final effluent has the least turbidity value of 30 NTU while the treated foundry effluent is 60 NTU. From appearance and odour, the stale leachate is the most disgusting and irritating.

3.2 Chemical Characteristics
Table 3 shows that pH of all the samples are within the specified Standards with the kitchen sample being the most acidic perhaps due to nature of the food wastes. Fresh leachate however shows the most alkaline pH value of 7.89. Leachate samples possess at least 10 times the values of electrical conductivity found in

Table 2: Mean results of the physical parameters as compared with the Effluent Standards

S/N	***Wastewater Source/Parameters***	***Colour***	***Odour***	***Temperature ^{0}C***	***Turbidity (NTU)***
1	BHN	Murky yellow	Objectionable	31.0	90
2	PGGHN	Clear	Objectionable	31.1	100
3	GHKN	Pinkish orange	Sharp pungent	30.2	800
4	WTPIN	Light brown	Pungent	31.7	170
5	WTPASN	Clear	Fairly objectionable	30.3	200
6	WTPFEN	Clear	None	30.7	30
7	MWKSN	Cloudy	Irritating	29.0	120
8	AUTOWWN	Dark black	None	31.6	350
9	CMLN	Dark ash	Repelling	30.7	390
10	FRIN	Slightly dark	Faint odour	30.7	90
11	FSSEN	Fairly clear	None	31.2	100
12	FFEN	Clear	None	31.5	60
13	WDFLV	Dark green	Objectionable	30.0	660
14	WDSLV	Dark brown	Pungent & Irritating	31.2	420
	CPCB Standard	Clear	unobjectionable	Not above 5^{0}C of receiving water	N/A
	EPA Standard	Clear	unobjectionable	Below 35^{0}C	N/A

N/A = Not Accessed

Table 3: Mean results of the chemical parameters as compared with the Effluent Standards

S/N	*Wastewater Source /Parameters*	*pH*	*Electrical Conductivity (mS/cm)*	*Chloride (mg/l)*	*COD (mg/l)*	*Sulphate (mg/l)*	*Nitrate (mg/l)*	*Phenol (mg/l)*	*Phosphate (mg/l)*
1	BHN	6.50	3080	2600	6400	25.0	24.0	105.0	4.20
2	PGGHN	6.23	4960	1600	6600	18.0	22.0	10.0	5.54
3	GHKN	4.47	8110	1400	32000	28.0	25.0	105.0	5.05
4	WTPIN	6.90	4900	800	38400	15.0	20.0	10.0	5.70
5	WTPASN	5.86	3750	450	16200	30.0	20.0	10.0	4.82
6	WTPFEN	6.30	1380	200	2560	12.0	10.0	9.9	3.86
7	MWKSN	6.45	7530	1200	19200	10.0	18.0	25.0	4.12
8	AUTOWWN	6.50	4530	400	41000	90.0	17.0	3950.0	3.70
9	CMLN	7.03	9000	1800	4200	10.0	22.0	225.0	4.20
10	FRIN	6.60	9820	400	25600	10.0	20.0	10.0	4.35
11	FSSEN	6.54	3980	99	19200	25.0	20.0	10.0	3.90
12	FFEN	6.63	3330	40	6400	10.0	18.2	10.0	3.84
13	WDFLV	8.37	76000	11700	44800	48.0	160.0	1010.0	85.4
14	WDSLV	7.89	96000	10399	51200	88.0	250.0	2200.0	58.6
	CPCB Standard *(mg/l)*	5.5 -9.0	N/A	1000	250	1000	N/A	1.0	5.0
	EPA Standard*(mg/l)*	6.0 -9.0	N/A	N/A	160	N/A	50	1.0	4.0

N/A = Not Accessed

Table 4: Mean concentration levels of trace elements in the samples compared with Effluent Standards

S/N	*Wastewater Source /Parameters*	*Cu (ppm)*	*Pb (ppm)*	*Mg (ppm)*	*Cr (ppm)*	*Ni (ppm)*	*Zn (ppm)*	*Mn (ppm)*	*Cd (ppm)*
1	BHN	0.4	6.7	30.4	0	0	2.3	0	0
2	PGGHN	3.0	12.0	28.2	0	0	5.3	0	0
3	GHKN	1.8	0	22.9	0	0	1.1	0	0.1
4	WTPIN	4.6	12.5	28.4	0	0	1.4	0.3	0
5	WTPASN	1.3	10.9	30.9	0	0	1.2	0.3	1.5
6	WTPFEN	2.7	10.0	28.1	0	0	0.8	0.3	0
7	MWKSN	3.8	8.2	33.4	8.9	3.6	3.4	0	0
8	AUTOWWN	0	11.6	55.3	0	0.3	14.2	0	1389.8
9	CMLN	2.4	14.4	22.0	15.6	0	0.5	0	0
10	FRIN	0	7.6	13.2	0	5.6	1.7	0	0
11	FSSEN	3.1	0	28.1	7.9	0	0.5	0	0
12	FFEN	0	5.1	11.3	0	0	0.9	0	0
13	WDFLV	0	25.9	417.4	0	0	0	0	943.3
14	WDSLV	26.7	2.6	821.6	0	0.9	11.6	0	1856.4
	CPCB Standard *(mg/l)*	3.00	0.1	N/A	3.00	3.00	5.00	1.0	2.00
	EPA Standard*(mg/l)*	3.00	1.00	N/A	2.00	1.00	5.00	2.00	0.03

N/A = Not Accessed

any other ones, in spite of their higher noticeable values. This may be linked to the various dissolved salts constituents usually being found in leachates. The same goes to explain the higher concentrations of their chloride, sulphate and phosphate when compared to those of other samples. It is generally observed that the pollution levels of the stale leachate all the measured chemical parameters are about one and half times that of fresh leachate, and extremely beyond the acceptable limits of the Standards. This is a pointer to the fact that the sampled stale leachate is still at its acetogenic stage with very high pollution potentials, as it has been reported that young leachate contains about 36 times COD value of stale ones (Ojoawo *et al.,* 2012). Other samples with relatively higher conductivity values are the kitchen, workshop, laundry and that of raw foundry wastewater.

The chloride concentration is observed to have been of the same trend in these samples, suggesting the fact that their conductivity levels were connected with the chlorides. Auto-Service wastewater shows a considerable concentration of COD, next to the leachate samples. The various treatments given to the lubricants and fuels could be responsible for this. Expectedly, its phenol level (3950.0 mg/l) exceeds those of others, aside from leachates, about 12 times. The presence of phenolic compounds is however in traces as far as domestic wastewaters are concerned. Only laundry and kitchen wastewaters show fairly higher values of phenols, perhaps due to their oily nature. All measured samples constitute phenol pollution as compared with the Standards. Figures 2 and 3 capture the concentration levels of the chemical parameters of all the samples. Sulphate concentration of 90 mg/l is observed as highest in the auto-service wastewater, this may be linked to the sulphur content of the lubricants. Stale leahate also possesses 88 mg/l of sulphate, this might have aggregated from decomposed chemical household and industrial products.

Nitrate and phosphorus values are generally higher in domestic samples than the commercial or industrial ones. This may be linked to remnants from agricultural application of fertilizers that are eroded into the storm-water and subsequently the domestic WTP. It has been reported that nitrate and phosphate values are generally more pronounced in the villages than in the city. This could be traced to the residual values of anions in fertilizers being used for agricultural purposes in these areas (Ojoawo et al., 2012). Meanwhile, the nitrate and phosphate concentrations in laundry and mechanical workshop wastewater samples are found mid-way of domestic and industrial. Except in the case of leachate samples, unlike phosphate, nitrate is not found to constitute pollution even in the untreated domestic and industrial wastewater samples.

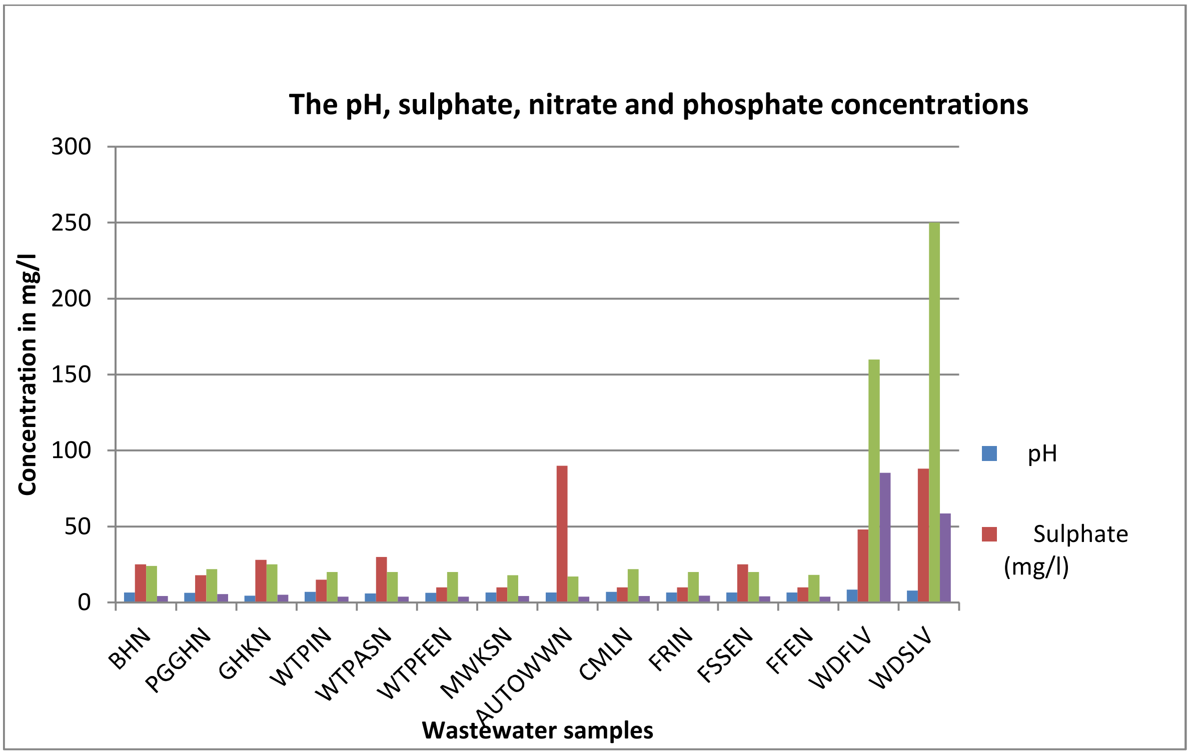

Fig. 2: The trend of the concentrations of pH, sulphate, nitrate and phosphate in the wastewater samples

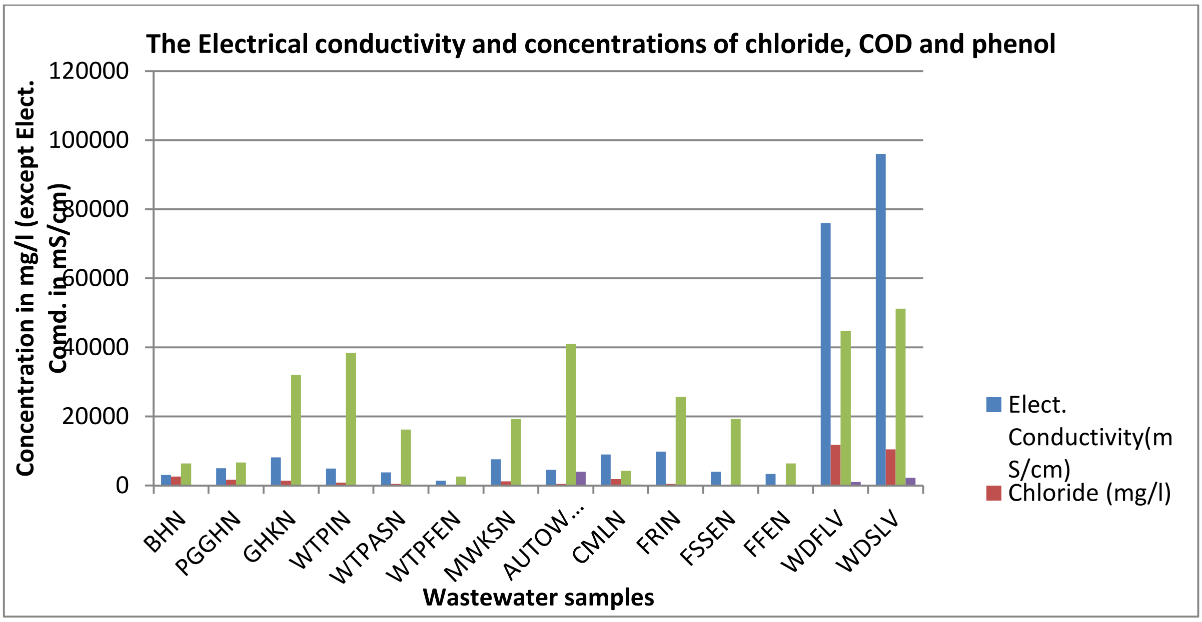

Fig. 3: The trend of the values of Electrical conductivity, chloride, COD and phenols in the wastewater samples

3.3 Trace metals concentration

Of all the measured metals, Cd found mainly in leachates, auto-service, and mechanical workshop samples has the highest concentrations and excessively pose pollution threat as compared with the Standards (Table 4). Stale leachate has 1856.4 ppm of Cd, a concentration that is extremely dangerous for human health by the Standards. The decomposed batteries from cars, motor-cycles, handsets, and the likes could have been the source of Cd in those samples. Cd has been found as one of the most common metal pollutants in wastewater discharged from industrial activities such as electroplating, smelting, alloy, pigment, metallurgy and refining (Farooq et al., 2010). On Cu, it is observed that the Stale Landfill Leachate has the highest concentration pollution of 26.7 compared with the recommended 3.00ppm. There are also traces of Cu pollution in Samples from the Wastewater Treatment Plant Inlet (4.6ppm), Central Workshop Wastewater (3.8ppm) and the Foundry Settled Sludge Effluent (3.1ppm). The Cu pollution is found to be marginal in the Postgraduate Girls' Hostel Wastewater. All the rest samples however did not constitute Cu pollution as far as the Standards are concerned.

Pb pollution above the Standard is found in practically all the samples except the Female Hostel Kitchen Greywater and in the Foundry Settled Sludge Effluent, due to the preliminary treatment it has undergone. Its concentration is low at the domestic sources like the Boys' and Postgraduate Girls' Hostel Wastewater; and also in the Commercial Laundry Wastewater. The highest pollution index of Pb is from Fresh Landfill Leachate. The Auto-Service Wastewater and industrial WTP's Inlet, have fairly high Pb pollution levels. This trend is similar to an earlier finding by Baysal *et al.,* 2013 that Cu, Zn, Ni and Pb are often detected in industrial wastewater originating from metal plating, mining, refining. Magnesium has its concentration is at its peak in the Stale Landfill Leachate sample (821.6ppm), and equally higher in the Fresh Landfill Leachate (417.4ppm). Mg is detected in all the tested samples with its least value being in the Female Hostel Kitchen Greywater. The rest samples are all permeated with Mg in one way or the other. The detection of Cr is only in three samples viz: Foundry Settled Sludge Effluent, Central Workshop Wastewater and in the Commercial Laundry Wastewater. Its presence constitutes pollution in the 3 samples when compared with the Standards. The highest concentration of 34.9ppm is observed in the Foundry works perhaps from the cooling water effluent discharged into the drains.

Ni is found in excess of the 1ppm EPA Standards in the Foundry Raw Inlet Wastewater, 5.6ppm (highest concentration), and in the Central Workshop Wastewater (3.6ppm), Its presence in both Auto-Service Wastewater and in the Stale Landfill Leachate samples are marginal and does not constitute pollution when compared with the Standards. The rest domestic wastewater samples do not have traces of Ni. Zn pollution is recorded in decreasing order from samples of Auto-Service Workshop Wastewater, Stale Landfill Leachate, Postgraduate Girls Hostel Wastewater, Central Workshop Wastewater, Boys' Hostel Wastewater, Auto-Service Workshop Wastewater, Wastewater Treatment Plant Inlet, Wastewater Treatment Plant Aerated Sewage, Female Hostel Kitchen Wastewater, Foundry Raw Inlet Wastewater, and to Foundry Settled Sludge Effluent. Zn is not detected in both Fresh Landfill Leachate and the Commercial Laundry Wastewater. The only sample containing Mn is the Aerated Sewage in the Wastewater Treatment Plant (2.3ppm), a value just slightly beyond the recommended safe EPA effluent of 2.0ppm. This has the capability of reacting with oxygen to form Manganese

Oxide.

3.4 Assessment of the WTPs

Domestic WTP drastically reduced the COD and Turbidity of the inlet wastewater by 93.3 and 82.4% respectively (Table 5). The chloride and electrical conductivities values are equally effectively minimized to 25 and 28% of respective initial concentration. Nitrate removed by 50%; phosphate, 33; sulphate, 20 and phenol compounds 1% treatment removal. Removal ability of the plant on nitrate and phosphate could be traced to the phytoremediation through a reed bed system of Canna *spp* linked with it. The respective removal percentages of metals by the domestic WTP in descending orders are: Zn, 43; Cu, 42; Pb, 20; and Mg, 1 (Table 6). On the other hand Industrial WTP attenuated the chloride to 10% of its initial value; COD, 25%; and electrical conductivity, 34% of values in the raw untreated wastewater. Turbidity removal is by about a third; nitrate and phosphate nearly a tenth; while sulphate and phenols are of same contents in the treated effluent. The corresponding metal removal percentages in the industrial WTP are: Ni, 100; Zn, 48; Pb, 33; and Mg, 15.

When the concentration of parameters in the final effluents are compared with the Standards, the Domestic WTP is found to be efficient in the attenuating the pollution of turbidity, chloride, sulphate, nitrate, phosphate, Zn, and Cu to the acceptable level. It considerably reduced the COD and electrical conductivity but not to the desired level of the Standards. Phenol compounds, Pb and Mg are barely treated in the process. Industrial WTP is however capable of satisfactorily remediating pollution caused by chloride, nitrate, phosphate, Ni and Zn to the prescribed levels by the Standards. It fairly treated turbidity, electrical conductivity, COD, Pb, and Mg but not to the acceptable concentration levels. It is incapable of remediating sulphates and phenols in the samples. Comparing the two, it is noted that domestic WTP is more suitable in remediating pollution due to turbidity, sulphate, nitrate and phosphate unlike the industrial one that is more efficient in treating chloride, Ni and Zn. Both reduced COD with domestic WTP being of better performance, but also not to a pollution-free concentration level. They are both found to be incapable of treating phenolic compounds in the samples even though the pH values are all within the specifications of the Standards. To complement the WTPs, some conventional methods of heavy metals removal such as ion-exchange, electro-winning, coagulation, cementation, reverse osmosis/electrodialysis, electro-coagulation, precipitation, and membrane separation could be introduced for tertiary treatments (Kang *et al.,* 2000; Sag and Kutyal, 2001; Wang and

Table 5: Percent removal of turbidity and the chemical parameters as compared in the WTPs

WTP	*Concentration/Parameters*	*Turbidity (NTU)*	*Electrical Conductivity (mS/cm)*	*Chloride (mg/l)*	*COD (mg/l)*	*Sulphate (mg/l)*	*Nitrate (mg/l)*	*Phenol (mg/l)*	*Phosphate (mg/l)*
Domestic	Influent concentration (WTPIN)	170	4900	800	38400	15.0	20.0	10.0	5.70
	Effluent concentration (WTPFEN)	30	1380	200	2560	12.0	10.0	9.9	3.86
	% Treatment Removal	82.4	71.8	75.0	93.3	20.0	50.0	1.0	32.3
Industrial	Influent concentration (FRIN)	90	9820	400	25600	10.0	20.0	10.0	4.35
	Effluent concentration (FFEN)	60	3330	40	6400	10.0	18.2	10.0	3.84
	% Treatment Removal	33.3	66.1	90.0	75.0	0	9.0	0	11.7

Table 6: Percent removal of the trace metals as compared in the WTPs

WTP	*Concentration/Parameters*	*Cu (ppm)*	*Pb (ppm)*	*Mg (ppm)*	*Cr (ppm)*	*Ni (ppm)*	*Zn (ppm)*	*Mn (ppm)*	*Cd (ppm)*
Domestic	Influent concentration (WTPIN)	4.6	12.5	28.4	0	0	1.4	0.3	0
	Effluent concentration (WTPFEN)	2.7	10.0	28.1	0	0	0.8	0.3	0
	% Treatment Removal	41.3	20.0	1.1	0	0	42.9	0	0
Industrial	Influent concentration (FRIN)	0	7.6	13.2	0	5.6	1.7	0	0
	Effluent concentration (FFEN)	0	5.1	11.3	0	0	0.9	0	0
	% Treatment Removal	0	32.9	14.4	0	100	47.1	0	0

Tang, 2001; Ahalya *et al.,* 2003; Wickramasingbe *et al.,* 2004; Kim *et al.,* 2005; Ahluwalia and Goyal, 2007; Baysal *et al.,* 2013).

4. Conclusion

The study characterized the physico-chemical parameters of the wastewater samples from residential, commercial and industrial sources in Nitte community and environs. It assessed the efficiencies of both the domestic and industrial WTPs in the study area based on the quality of their effluents as compared with the EPA and BCBP Standards. It concludes that the main physico-chemical parameters that are of pollution concern in the domestic wastewater of the study area include electrical conductivity, chloride, COD, phenol compounds, phosphate, Cu, Pb, and Mg. Pollutants in the industrial wastewater encompass Cr and Zn in addition to those of domestic wastewater, while Cd is a key pollutant in leachates aside those identified in domestic and industrial wastewater samples. Domestic WTP is more suitable in remediating pollution due to turbidity, sulphate, nitrate and phosphate unlike the industrial one that is more efficient in treating chloride, Ni and Zn. Both reduced COD with domestic WTP being of better performance, but also not to a pollution-free concentration level. Both are however found to be incapable of treating phenolic compounds in the samples. Further treatment methods like bioremediation, ion-exchange and adsorption are therefore recommended in addition to the existing ones in the study area.

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