Scientific Research

Susceptibility of Some Selected Nitte Municipal Wastewater Sources to Trace Metals Pollution

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Abstract

The negative impacts of pollution due to trace metals in wastewater on aquatic ecosystem and related organisms in water bodies are on the increase. This paper deals with the investigation on the pollution indices of trace metals in selected wastewater samples of Nitte Town, Udupi District, Karnataka State, India. Twelve wastewater samples were obtained from Students Hostels, Auto-Service Workshop Station, Foundry, Laundry, Landfill Leachate and Wastewater Treatment Plant Inlet. The measured heavy metals in the samples include: Copper (Cu), Lead (Pb), Magnesium (Mg), Chromium (Cr), Nickel (Ni), Zinc (Zn), Manganese (Mn) and Cadmium (Cd), using the air-acetylene-operated Flame Atomic Absorption Spectrometer (FAAS), Avanta GM model. The results were all compared with the EPA Effluent Standards. Findings revealed that all samples recorded dwindling levels of trace metals pollution when compared with the Standards. The heaviest concentration occurred in Cd with as high as 1856.4 ppm as found in the Stale Landfill Leachate sample, while the least contaminating metal in the samples is Manganese which was detected in only Aerated Wastewater Treatment Plant sample (2.3 ppm). This study is therefore recommending Electro-coagulation treatment method for trace metals with high concentration levels like Cd, Pb, Mg and Cu, while those with lesser concentration such as Mn, Cr, Ni and Zn in the samples are suggested to be treated with chemical precipitation method.

Keywords

Trace Metals, Municipal Wastewater, Pollution, Nitte

1. Introduction

The term "*trace metal*" includes a number of chemical elements that occur in natural systems in small concen-

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trations. Boron (B), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn), widely used in industrial processing and in manufacturing of consumer goods, are the most common trace metals in municipal wastewaters [1]. In another report [2] expanded the trace metal's list to include arsenic (As), silver (Ag), and iron (Fe). It has been noted that the significant part of the anthropogenic emissions of heavy metals ends up in wastewater [3]. Most of the industrial sources of trace metals include surface treatment processes with elements such as Cd, Pb, Mn, Cu, Zn, Cr, Hg, As, Fe and Ni, as well as industrial products that, at the end of their life, are discharged in wastewater. In urban centers, volume of sewage water increases through household effluents, drainage water, business effluents (e.g., car washes, dental uses, other enterprises, etc.), atmospheric deposition, and traffic related emissions (vehicle exhaust, brake linings, tires, asphalt wear, gasoline/oil leakage, etc.) transported with storm water into the sewerage system [4] [5].

According to the [6] European Commission (2002), most common sources of heavy metals to waste water are Mining and extraction—by mining and extraction a part of the heavy metals will end up in tailings and other waste products. A significant part of the turn-over of the four heavy metals with mining waste actually concerns the presence of the heavy metals in waste from extraction of other metals like zinc, copper and nickel; Primary smelting and processing—a minor part of the heavy metals will end up in waste from the further processing of the metals; Use phase—a small part of the heavy metals may be lost from the products during use by corrosion and wear. The lost material may be discharged to the environment or end up in solid waste either as dust or indirectly via sewage sludge; Waste disposal—the main part of the heavy metals will still be present when the discarded products are disposed of. The heavy metals will either be collected for recycling or disposed of to municipal solid waste incinerators (MSWI) or landfills or liquid waste. A minor part will be disposed of as chemical waste and recycled or land-filled via chemical waste treatment, volcanic eruptions, fossil fuel combustion, agriculture, erosions, and metallurgical industries.

It has been established that many of the trace metals are necessary for human health. Iron, copper, zinc, nickel and other trace elements are needed for proper functioning of biological systems, but their over-exposure can lead to adverse health consequences [7]-[9]. For instance, child lead poisoning causes delayed brain development or acute brain problems and also affects the safety of aquatic organisms at a concentration of 0.16 mg/l [10]. Excessive chromium in humans causes mouth ulcers, nosebleeds, kidney disease, low white blood cell counts and a variety of cancers [11]. Zinc is found naturally in rocks, air, water and soil. The average human body system contains about 3 g of zinc, the highest levels being in muscles, liver, kidneys, bones and prostate. The recommended daily zinc intake is 12 mg/day for adult women and 15 mg/day for adult men. Uptake of too much of the trace element can lead to toxicity, such as that, high doses of zinc can lead to gastro-intestinal disorders. On the other hand, deficiencies of some of these trace elements may equally lead to a number of disorders [12]. When uptake of zinc, for example is too low, deficiency occurs in form of reduced sense of taste and smell, skin disorders, mental lethargy and reduced fertility.

In order to determine the heavy trace metals, there are many inorganic techniques [13] such as: Flame Atomic Absorption Spectrometry (FAAS), Graphite Furnace (or Electrothermal) Atomic Absorption Spectrometry (GFAAS or ETAAS), Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES), Inductively Coupled Plasma Mass Spectrometry (ICP-MS), Anodic Stripping, and Laser Induced Breakdown Spectroscopy (LIBS), among others. The main factors influencing the choice of technique include: the number of elements to be determined, expected concentration range of analytes, and the number of samples to be run.

The main objective of this paper is to investigate the levels of concentrations of selected trace metals in the municipal waste water of Nitte Community with a view to determining their pollution status.

2. Methodology

2.1. The Study Area

The study area is Nitte, a town in Karkal Taluk in Udupi District of Karnataka State, India. The sampling locations are on the Campus of the NMAM Institute of Technology: an Auto-workshop, a Laundry, a Foundry, Landfill leachate, and a Waste Treatment Plant, all within the neighbourhood of Nitte Settlement. It is located 30 km towards East from District head quarters Udupi, 10 km from Karkal and 336 km from the State capital Bangalore. The study area's elevation/altitude is 20 meters above mean sea level. Udupi district experiences a typical maritime climate with an average temperature of 26.5°C. The district gets highest annual rainfall in Karnataka state, about 4000 mm [14] (Ojoawo and Udayakumar, 2014). The study area and layout plan of NMAMIT campus are

presented in **Figure 1** and **Figure 2** respectively.

2.2. Sampling

Sampling was done using Standard Methods. Twelve concordant samples were collected and analyzed from the wastewater emanating in the study area. In addition to this, a blank sample was prepared for calibration in each measurement process while five Standard samples of known concentrations were employed in the measurement, making a total of eighteen being analyzed. **Table 1** gives the details of the Samples and their representations.

2.3. Laboratory Analysis

Samples were analyzed using the FAAS, Avanta GM model, of the Department of Bio-Technology, NMAM Institute of Technology, Nitte as shown in **Figure 3** and **Figure 4**. The FAAS's main specifications include: sensitivity of up to ppb level; two channels (independent or simultaneous); wavelength range of between 180 nm and 900 nm; and probe of teflon tubing—1.6 mm OD (0.8 mm ID).

The equipment was calibrated using the prescribed procedures. The five Standard samples of pre-determined concentrations on each of the element were used in the correlations of the absorbance with the concentration. Eight trace elements were measured in each of the samples; these include Cu, Mg, Pb, Cr, Ni, Zn, Mn, and Cd. The flame used in the analysis was air-acetylene. The temperature formed in the air-acetylene flame was around 2300°C. The FAAS technique made use of the fact that neutral or ground state atoms of an element can absorb electromagnetic radiation over a series of very narrow, sharply defined wavelengths. The sample in solution was aspirated as a fine mist into a flame where it was converted into atomic vapor. Most of the atoms remained in the ground state and were therefore capable of absorbing radiation of a suitable wavelength. This discrete radiation was supplied by a hollow cathode lamp, which a sharp line source consisting of a cathode was containing the element to be determined along with the tungsten anode. The line characteristic of the element were emitted by the hollow cathode and passed through the flame where they were absorbed by the atomic vapor, since only the test element can absorb this radiation, the method became specific.

The block diagram of the FAAS or GFAAS is shown in **Figure 5** while the details of samples and instrumentations are in **Table 2**. The samples were all introduced manually and two replicate samples were measured for each of the elements.

3. Results and Discussion

The results of concentration levels of each trace element in the samples compared with the Environmental Protection Agency (EPA) Effluent Standards of 1998 are presented in **Table 3**.

From the table it is generally observed that for all the measured trace metals in the sewage samples there are dwindling levels of pollution recorded when values are compared with the EPA Standards. Magnesium could however not be compared due to the unavailability of its permissible recommended value on the consulted EPA Standard. The trends of pollution levels in the samples, as compared with EPA standards, are as displayed in **Figures 6-12**.

The results of the concentration levels of each of the trace elements are discussed below:

Copper (Cu)—It is observed that the Stale Landfill Leachate has the highest concentration pollution of 26.7 compared with the recommended 3.00 ppm. There are also traces of Cu pollution in Samples from the Wastewater Treatment Plant Inlet (4.6 ppm), Central Workshop Wastewater (3.8 ppm) and the Foundry Settled Sludge Effluent (3.1 ppm). 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.

Lead (Pb)—Pollution above the Standard is found in practically all the samples except the Female Hostel Kitchen Greywater and in the Foundary 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, Wastewater Treatment Plant's Inlet, and the Aerated Wastewater at the Treatment Plant have fairly Pb pollution levels.

Magnesium (Mg)—Its concentration is at its peak in the Stale Landfill Leachate sample (821.6 ppm), and equally higher in the Fresh Landfill Leachate (417.4 ppm). Mg is detected in all the tested samples with its least

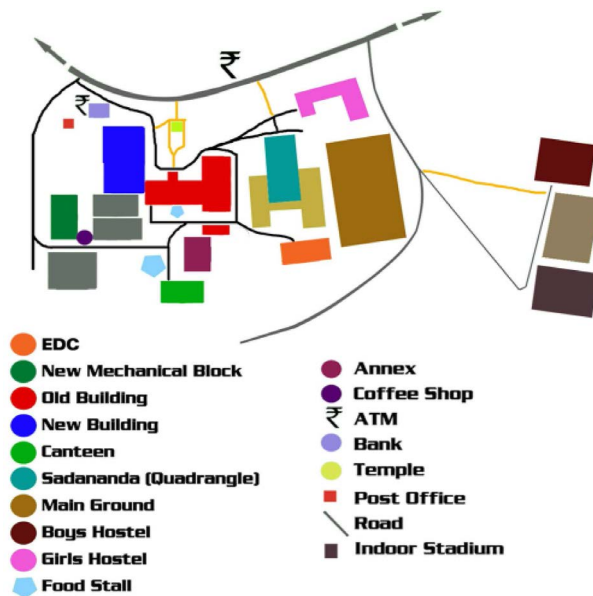**Figure 1.** Map of udupi district of Karnataka state.

Figure 2. The layout plan of Nmamit campus.

Figure 3. The Avanta GM FAAS used for the analysis.

Figure 4. Determination of the trace elements in wastewater samples using the FAAS.
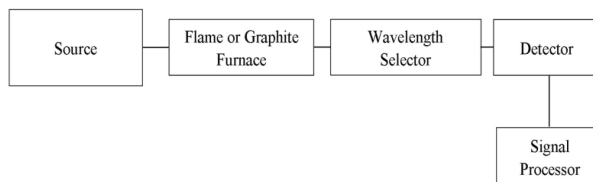

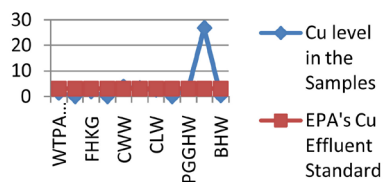**Figure 5.** The block diagram of FAAS or GFAAS.

Figure 6. Comparison of Cu level in the samples with the EPA Effluent Standards.

value being in the Female Hostel Kitchen Greywater. The rest samples are all permeated with Mg in one way or the other.

Chromium (Cr)—The detection of Cr is only in three samples viz: Foundry Settled Sludge Effluent, Central
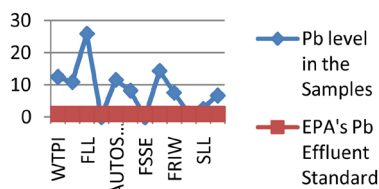
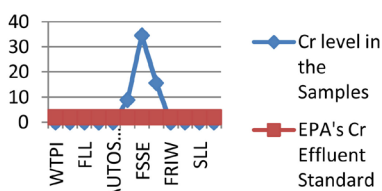**Figure 7.** Comparison of Pb level in the samples with the EPA Effluent Standards.

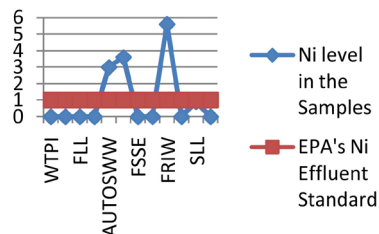**Figure 8.** Comparison of Cr level in the samples with the EPA Effluent Standards.

Figure 9. Comparison of Ni level in the samples with the EPA Effluent Standards.
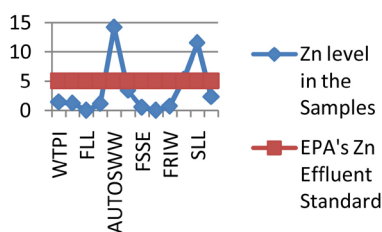
Figure 10. Comparison of Zn level in the samples with the EPA Effluent Standards.
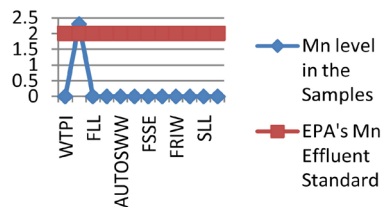
Figure 11. Comparison of Mn level in the samples with the EPA Effluent Standards.

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 34.9 ppm is observed in the Foundry works perhaps from the cooling water effluent discharged into the drains.

Nickel (Ni)—This is found in excess of the 1 ppm Standards in the Foundry Raw Inlet Wastewater, 5.6 ppm
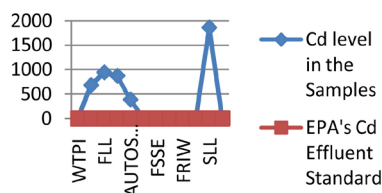
Figure 12. Comparison of Cd level in the samples with the EPA Effluent Standards.

Table 1. Samples and their representations.

S/N	Sample Label	Description
1	Sample 0	Blank Sample for Calibration
2	Standard 1	First Standard Sample of Known Concentration
3	Standard 2	Second Standard Sample of known concentration
4	Standard 3	Third Standard Sample of known concentration
5	Standard 4	Fourth Standard Sample of known concentration
6	Standard 5	Fifth Standard Sample of known concentration
7	WTPI	Wastewater Treatment Plant Inlet
8	WTPAWW	Wastewater Treatment Plant Aerated Wastewater
9	FLL	Fresh Landfill Leachate
10	FHKG	Female Hostel Kitchen Greywater
11	AUTOSWW	Auto-Service Workshop Wastewater
12	CWW	Central Workshop Wastewater
13	FSSE	Foundry Settled Sewage Effluent
14	CLW	Commercial Laundry Wastewater
15	FRIW	Foundry Raw Inlet Wastewater
16	PGGHW	Postgraduate Girls' Hostel Wastewater
17	SLL	Stale Landfill Leachate
18	BHW	Boys' Hostel Wastewater

Table 2. The sample and instrumentation details.

S/N	Element	Instrument Parameters			Sample Measurement Parameters		
		Lamp current (mA)	Wavelength (nm)	Slit width (nm)	Measurement mode	Read time (s)	Replicates
1	Cu	3.00	327.40	0.50			
2	Pb	5.00	217.00	1.00			
3	Mg	3.00	202.60	1.00			
4	Cr	6.00	359.30	0.20			
5	Ni	4.00	341.50	0.20	Integration	2.00	2
6	Zn	5.00	213.90	0.50			
7	Mn	5.00	403.10	0.20			
8	Cd	3.00	326.10	0.50			

(highest concentration), and in the Central Workshop Wastewater (3.6 ppm). It's presence in both Auto-Service Wastewater and in the Stale Landfill Leachate samples is marginal and does not constitute pollution when compared with the Standards. The rest domestic wastewater samples do not have traces of Ni.

Zinc (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 Set-

Table 3. Concentration levels of trace elements in the samples compared with EPA Effluent Standards.

S/N	Sample	Cu (×10² ppm)	EPA ES	Pb (×10² ppm)	EPA ES	Mg (×10² ppm)	EPA ES	Cr (×10² ppm)	EPA ES	Ni (×10² ppm)	EPA ES	Zn (×10² ppm)	EPA ES	Mn (×10² ppm)	EPA ES	Cd (×10² ppm)	EPA ES
						Average concentration of trace elements compared with the EPA Effluent Standards, EPAES											
1	Blank Sample	-		-		-		-		-		-		-		-	
2	Standard 1	2.00		2.00		5.00		5.00		5.00		0.50		5.00		5.00	
3	Standard 2	4.00		4.00		10.00		10.00		10.00		1.00		10.00		10.00	
4	Standard 3	6.00		6.00		15.00		15.00		15.00		1.50		15.00		15.00	
5	Standard 4	8.00		8.00		20.00		20.00		20.00		2.00		20.00		20.00	
6	Standard 5	10.00		10.00		-		-		-		-		-		-	
7	WTPI	0.046		0.125		0.284		ND		ND		0.014		ND		ND	
8	WTPAWW	0.013		0.109		0.309		ND		ND		0.012		0.023		6.815	
9	FLL	ND	3.00	0.259	1.00	4.174	N/A	ND	2.00	ND	1.00	ND	5.00	ND	2.00	9.433	0.03
10	FHKG	0.018		ND		0.229		ND		ND		0.011		ND		8.731	
11	AUTOSWW	ND		0.116		0.553		ND		0.003		0.142		ND		13.898	
12	CWW	0.038		0.082		0.334		0.089		0.036		0.034		ND		ND	
13	FSSE	0.031		ND		0.281		0.349		ND		0.005		ND		ND	
14	CLW	0.024		0.144		0.220		0.156		ND		ND		ND		ND	
15	FRIW	ND		0.076		0.132		ND		0.056		0.007		ND		ND	
16	PGGHW	0.030		0.120		0.282		ND		ND		0.053		ND		ND	
17	SLL	0.267		0.026		8.216		ND		0.009		0.116		ND		18.564	
18	BHW	0.004		0.067		0.304		ND		ND		0.023		ND		ND	

Notes: N/A = Not Available; ND = Not Detected.

tled Sludge Effluent. Zn is not detected in both Fresh Landfill Leachate and the Commercial Laundry Wastewater.

Manganese (Mn)—The only sample containing Mn is the Aerated Sewage in the Wastewater Treatment Plant (2.3 ppm), a value just slightly beyond the recommended safe EPA effluent of 2.0 ppm. This has the capability of reacting with oxygen to form Manganese Oxide.

Cadmium (Cd)—Five samples have heavy Pollution from Cd while the rest do not possess its traces. Compared with the EPA standards, the Stale Landfill Leachate causes the most Cd pollution of about 1856.4 ppm, followed by the Auto-Service Workshop Wastewater (1389.8 ppm). The other samples causing Cd pollution as compared with the Standards are Fresh Landfill Leachate (943.3 ppm), Female Hostel Kitchen Wastes (873.1 ppm) and Aerated Wastewater of the Treatment Plant (681.5 ppm).

4. Conclusion

The study has looked into the possible pollution arising from the concentration of trace metals in the twelve selected wastewater samples in Nitte Community, Udupi District, India. The measured heavy metals; Cu, Pb, Mg, Cr, Ni, Zn, Mn and Cd all constituted pollution when compared with the EPA Effluent Standards. The heaviest concentration occurred in Cd with as high as 1856.4 ppm as found in the Stale Landfill Leachate sample, while the least contaminating metal in the samples is Manganese which was detected in only Aerated Wastewater Treatment Plant sample (2.3 ppm). This study is therefore recommending Electro-coagulation treatment method for metals in high concentration like Cd, Pb, Mg and Cu, while those with lesser concentration such as Mn, Cr, Ni and Zn are to be treated with chemical precipitation.

Acknowledgements

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