ISSN(online) : 2349-6010

Physio-Chemical Analysis of Waste Water using Surfactant Assemblies

DR.Supriya Biswas
Professor
Department of chemistry
Shri shankarachrya group of institutions,junwani ,Bhilai.

Mrs.Pratibha S.Kurup
Asst. Professor
Department of chemistry
chhatrapati shivaji institute of technology,balod road,durg,C.G

Abstract

This paper presents the effect of surfactant on the physiochemical analysis of waste water. Eight different locations were selected for the study and compared. The parameters studied were pH, total alkalinity, total hardness, total dissolved solids, conductivity, Acidity, free carbon dioxide, metal analyzed are Calcium, Magnesium, Copper , Nickel , Iron. From overall analysis, it was observed that the physico-chemical parameters of the waste water samples studied with the addition of surfactant showed remarkable changes. Metal analysis showed reduction in data which clearly shows that metal formed complexes with surfactant assemblies and surfactants can be used for metal detection.Corelation analysis was also carried out.
Keywords: Surfactant, Physico-Chemical analysis, Correlation analysis.

I. INTRODUCTION

Water is a vital natural resource, which is essential for multiplicity purposes. It is an essential constituent of all animal and plant life. Its major uses include drinking and other domestic uses, industrial cooling, power generation, agriculture, transportation and waste disposal However, pure water is needed for human consumption does not always occur in nature, due to the presence of dissolved or suspended impurities in most natural water bodies (Goldface, 1999). Also the availability of good quality water is an indispensable feature for preventing diseases and improving quality of life (Oluduro and Aderiye, 2007). Growing population, accelerating pace of industrialization and intensification of agriculture and also urbanization exert heavy pressure on our vast but limited water resources. There are various ways as ground water is contaminated such as use of fertilizer in farming (Altman and Parizek,1995), seepage from effluent bearing water body(Adekunle, 2009).

II. WATER POLLUTION

The term water pollution refers to anything causing change in the diversity of aquatic life. The presence of too much of undesirable foreign substance in water is responsible for water pollution. Also, Heavy metal water pollution is a serious environmental problem. Most of the industries discharge their effluent without proper treatment into nearby open pits or pass them through unlined channels, resulting in the contamination of ground water (Jinwal and Dixit, 2008).The incidence of ground water pollution is highest in urban areas where large volumes of waste are concentrated and discharge into relatively small areas (Rao and Mamatha, 2004). These waste release organic as well as metal ions to the water resource. The metal ions are non-biodegradable, highly toxic and may have a potentially carcinogenic effect. If directly discharged into the sewage system, they may seriously damage the operation of biological treatment plants. The presence of metal ions in the environment is of major concern due to their toxicity to many life forms. Unlike organic pollutants, the majority of which are susceptible to biological degradation, metal ions do not degrade into harmless end-products. The metals of most immediate concern are Cr, Mn, Fe, Zn, and Cd. These metals are widely distributed in materials which make up the earth's surface (Dean et al., 1972)

Wastewater containing dissolved metal ions such as zinc, cadmium, nickel and copper originate from a variety of sources such as metal mine-tailing leachate, refineries, semi-conductor manufacturing, battery, abandoned metal mines and metal plating industries. At present, the traditional techniques for the removal of metal ions from Wastewaters that are in practice include adsorption, extraction, precipitation, electrolytic method, ion exchange method, and distillation. However, these techniques have their own disadvantages, such as inconvenient operation, secondary pollution of deposition, loss of expensive chemicals, difficulty in recovering Metal ion, strong pH sensitivity, incapable of reducing metal ions concentration to the levels required by law and so on. Since water is the vital concern for mankind and essential for man, animal and aquatic. It is the universal enabling chemical which is capable of dissolving or carrying in suspension of a variety of a toxic materials from mainly heavy flux of sewage, industrial effluents, domestic and agricultural waste. That is why it is of special interest to study the water pollution.

A. Objective of the present work

Waste originated from the above industries are treated in waste water treatment plants The major function of the wastewater treatment plant is to reduce the organic loading of domestic wastewater so that it can be safely discharged to a receiving stream.

Essential unit processes are biological treatment and sedimentation. In the present study, an attempt is made to analyze the desirable and essential characteristics from the waste water collected from different industry i.e. rice mill, Dal mill and iron and steel industry using anionic surfactant sodium lauryl sulphate (SLS) at low concentrations in order to reduce the expense of the process and the secondary pollution.

B. Role of surfactants

Surfactants are substances which alter the surface properties of liquids, even when present in small quantities. Composed of two fractions, a lyophilic group and a lyophobic group, surfactants migrate to the surface, resulting in the lyophilic portion lying within the solution and the lyophobic group orienting itself away from the solution. This orientation of the surfactant reduces the free energy of the surface, thus decreasing surface tension and increasing surface viscosity. Diffusion of surfactants to the surface continues until equilibrium is established. (Masutani G., Stenstrom M.K).

1) *Parameters*

Tests were done and results were analyzed on the base of the Indian Standard: Drinking water – Specification IS: 10500: 1991.Water quality characteristic of aquatic environment arise from a multitude of physical, chemical and biological interactions (Deuzane, 1979; Dee, 1989).The standard categories various characteristics as essential or desirable. The Standard also mentions the desirable limit, permissible limit in the absence of alternate source and indicates their background. Short description of meaning and significance for the health and environmental the measured parameters:

a) Odour

Odour is recognized as a quality factor affecting acceptability of drinking water and food prepared from it, tainting of fish and other aquatic organisms and aesthetics of recreational waters. Most organic and some inorganic chemicals contribute taste or odour.

b) Turbidity

Turbidity is an important parameter for characterizing water quality. It is an

Expression of optical property of a sample (water and wastewater) containing insoluble substance which causes light to be scattered rather than transmitted in straight lines. In most of the waters.

c) Colour

Colour in water may be due to the inorganic ions, such as iron and manganese, humus and peat materials, plankton, weeds and industrial wastes.

d) Total Dissolved Solids

"Total Dissolved solids" refer to any minerals, salts, metals, cations or anions dissolved in water. This includes anything present in water other than the pure water molecule and suspended solids for eg wood pulp. Many dissolved substances are undesirable in water.

e) Health risks:

Water with higher solids content often has a laxative and sometimes the reverse effect upon people whose bodies are not adjusted to them. High concentration of dissolved solids about 3000 mg/l may also produces distress in livestock.

f) pH

pH is a term used universally to express the intensity of the acid or alkaline

It is a measure of Hydrogen Ion concentration PH is defined as the "logarithm (base 10) of the reciprocal of the Hydrogen Ion concentration."

g) Health risks:

It influences the growth of plants and soil organism, therefore, it affects to a great extent, the suitability of water for irrigation.

h) Conductance

Electrical Conductivity is a measure of water's capacity of conveys electric current. The unit of Conductivity is µmho/cm

i) Total Hardness

The term "Total Hardness" indicates the concentration of Calcium and Magnesium Ions only. The Total Hardness is expressed in terms of Calcium Carbonate. The analysis was done by complexometric titration.

j) Alkalinity

The Alkalinity of natural or treated water is normally due to the presence of Bicarbonate, Carbonate -and Hydroxide compounds of Calcium, Magnesium, Sodium and Potassium.

Metal analysis;

2) *Calcium*

a) Source

The presence of Calcium in water is mainly due to its passage through or over deposits of Lime Stone, Dolomite, Gypsum and other Gypsiferous Materials.

b) Importance

Calcium is a substantial component of bones and teeth. it is essential for maintaining total body health, normal growth and development, ensuring the proper functioning of muscles and nerves, regulating blood pressure,metabolising iron.

c) Health risks

Excessively intakes of calcium can interfere with the absorption of zinc, magnesium, iron, phosphorus and other nutrients. This may result in calcium deposits in places such as the kidneys, the arteries and the heart.

d) Desirable limit

Calcium is usually one of the most important contributors to hardness. Human body requires approximately 0.7 to 2.0 grams of calcium per day.

3) *Magnesium*

a) Source Importance

Magnesium plays an important role as a cofactor and activator of more than 300 enzymatic reactions including glycolysis.

b) Health risks

Magnesium toxicity causesdamage to kidney

c) Desirable limit

Acc. to Standard for Drinking Water (BIS 105000) Desirable Limit: 30 mg/L, Permissible limit in the absence of an alternative source: 100 mg/L

4) *Iron*

a) Source

Iron is one of the most abundant trace metals on Earth and is an important constituent of forest soils.

b) Importance

Iron is an essential for the formation of haemoglobin and certain enzymes.

c) Health risks;

iron may accumulate in body tissues and organs when normal storage sites are full.

5) *Copper*

a) Source

The major sources of copper in drinking water are industries, corrosion of household plumbing systems; and erosion of natural deposits.

b) Importance

Copper is a trace mineral that works with iron in the manufacture of red blood cells, as antioxidant.

c) Health risks;

Short- and long-term effects: Copper is an essential nutrient, required by the body in very small amounts. However, EPA has found copper to potentially cause the following health effects when people are exposed to it at levels above the Action Level. Short periods of exposure can cause gastrointestinal disturbance, including nausea and vomiting. Intakes in excess of 10 mg can cause vomiting, diarrhea, muscular pain, depression, irritability, nervousness and dementia. Toxicity is low and very rare.

d) Desirable limit

For copper in potable water is 0.05 mg/l maximum which can be relaxed in the absence of better alternate source to 1.5 mg/l.

III. MATERIAL AND METHOD

Essential characteristics we analyzed in the waste water from eight industries of Durg Bhilai area are:

ESSENTIAL PARAMETERS	***DESIRABLE PARAMETERS***
Colour	*Total dissolved solids*
Odour	*Calcium*
pH	*Copper*
conductivity	*Magnesium*
Total hardness	*Iron*
Acidity	*Nickel*
Free carbon dioxide	*Alkalinity*

Parameters we analyzed which are not in standard: Conductivity,pH

A. Sampling

Eight effluent samples from each site of the discharge outlets points of different industrial unit's i.e rice mill, iron and steel industry and Dal mill, food processing unit, Slaughter house, button factory, sugar processing unit were collected and analyzed. Normal tap water from durg area was collected in the fresh polymeric bottles and brought to the laboratory for various chemical parameters analyses.

Method;

B. Analysis of Essestial Parameters

Temperature (°C), pH and Electrical Conductivity (EC) in µscm-1 were determined after collection of the water samples, using a Mercury Thermometer, pH meter and a Conductivity meter (APHA, 1998). The total dissolved solid or residue was calculated from the relationship: TDS= 0.01 EC The colour of the water was measured by the use of a visual comparator matching the colour of the sample with standard (APHA, 1989; Ademoroti, 1996). Odour was determined using the sense organs for smell. The Total Hardness (mg/l $CaCO_3$) was determined using EDTA Titremetric method, and other parameters were determined according to Ademoroti, 1996 and Andrew et.al. 1995.

C. Metal Analysis

Complexometric titration and Standard Analytical method were used for the determination of metals.

D. Aliquot prepration

Two sets of sample were prepared, one for standard reading (without surfactant) and with Surfactant.

E. Statistical Analysis

The mean, Standard deviation and correlation analysis of the results were carried out. The metal concentrations were comparably analyzed by bar graph.

Correlation coefficient: Correlation coefficient (r) was calculated to know the relationship in between the effect of addition of surfactant by using the following formula: (Kamal D. et al 2007).

Table 1.1: Analysis of Essential parameters without adding surfactant

parameters	***Wws1***	***Wws2***	***Wws3***	***Wws4***	***Wws5***	***Wws6***	***Wws7***	***Wws8***	***mean***	***S.D***
Conductivity	*590*	*620*	*770*	*658*	*646*	*714*	*601*	*747*	*668.25*	*67.84593892*
Total hardness	*265.5*	*252.3*	*299*	*405*	*302*	*381*	*322*	*558*	*348.1*	*99.7107674*
pH	*7.2*	*7.23*	*7.3*	*6.31*	*7.05*	*6.98*	*7.15*	*6.1*	*6.915*	*0.4530216*
Colour	*pale yellow*	*brown*	*grey*	*pale yellow*	*Brown*	*pale yellow*	*pale yellow*	*Dark grey*		
Temp.	*21*	*21*	*23*	*23*	*24*	*22.5*	*23.1*	*24.5*	*22.7625*	*1.25690948*
Acidity	*20*	*9*	*25*	*14*	*3*	*3*	*9*	*15*	*12.25*	*7.79651937*
Free co2	*30.8*	*13.2*	*39.6*	*44*	*26.4*	*17.6*	*22*	*35.2*	*28.6*	*10.7777549*

Table 1.2: Analysis of Desirable parameters without adding surfactant

parameters	Wws1	Wws2	Wws3	Wws4	Wws5	Wws6	Wws7	Wws8	mean	S.D
Alkalinity	153.12	136.13	112.29	234	355	138.11	446	149	215.45625	121.9996266
TDS	306.05	321.79	430.23	341.69	335.4	370.93	311.83	390.2	351.015	43.01044325
Calcium	179.2	163.8	201	210	161	185	209	221	191.25	22.35933809
Magnesium	86	89.3	98	195	141	196	113	337	156.9125	85.07326989
Copper	7.39	6.25	1.6	6.41	8.1	3.12	7.39	6.3	5.82	2.267471846
Nickel	.53	0.78	0.23	0.13	0.21	0.3	0.12	0.2	0.3125	0.228770003
Iron	121	176	410	714	532	756	966	414	511.125	290.9675669

Table 2.1 Analysis of Essential parameters with surfactant

parameters	Wws1	Wws2	Wws3	Wws4	Wws5	Wws6	Wws7	Wws8	mean	S.D
Conductivity	630	920	820	710	729	789	689	764	756.375	88.92522943
Total hardness	239.5	214.5	250	375	292	352	296	495	314.25	91.24535213
pH	7.5	7.35	7.6	6.49	7.29	7.1	7.26	6.9	7.18625	0.355926858
Colour	pale yellow	brown	grey	pale yellow	brown	pale yellow	pale yellow	Dark grey	------	--------
Temp.	21	21	23	23	24	22.5	23.1	24.5	22.7625	1.256909475
Acidity	6	3	5	7	6	5	15	20	8.375	5.902481318
Free co2	17.6	17.6	39.6	48.4	35.2	26.4	30.8	48.4	33	12.22082532

Table 2.2: Analysis of Desirable parameters with surfactant

parameters	Wws1	Wws2	Wws3	Wws4	Wws5	Wws6	Wws7	Wws8	mean	S.D
Alkalinity	162.2	155.1	123	249.1	385.2	149.2	468	161	231.6	127.6271691
TDS	327	374.91	431.56	368.69	380	413.99	357.89	399.2	381.655	32.97652368
Calcium	165.5	133.2	165	194	154	168	187	201	170.9625	22.29054492
Magnesium	75	81.3	85	181	138	184	109	294	143.4125	74.54675307
Copper	2.13	5.21	1.1	4.12	5.12	1.5	5.29	5.2	3.70875	1.825035714
Nickel	.28	.23	.19	.1	.14	.1	.08	.15	0.15875	0.069987244
Iron	98	110	209	519	336	583	728	346	366.125	228.3014533

Correlation analysis of the data without and with surfactant

s/n	Parameters	(r)value
1	Conductivity	.38302
2	Total hardness	.9896
3	pH	.8687
4	Temp.	1
5	Alkalinity	.9999
6	TDS	.9141
7	Calcium	.9132
8	Magnesium	.7397
9	Copper	.7525
10	Nickel	.7999
11	Iron	.9814
12	Acidity	.7312
13	Free co2	.9732

TABLE:4.1 Correlation :coefficent matrix showing the relation between desirable parameter without adding surfactant

	pH	Conductivity	Total Hardness	Acidity	Free Co2
pH	1				
Conductivity	0.9916	1			
Total Hardeness	-0.9118	0.975	1		
Acidity	0.0072	0.868	-0.01306	1	
Free Co2	-0.5046	0.9511	0.389	0.6732	1
TDS	0.2041	0.999	0.4235	0.3985	0.4349
Alkalinity	0.07356	0.8565	-0.1183	-0.4529	-0.1283
Calcium	-0.6238	0.4335	0.7165	0.4217	0.5979
Magnesium	-0.9041	0.5371	0.9828	-0.1272	0.2971
Copper	-0.1792	-0.7624	-0.0406	-0.3385	-0.1345
Nickel	0.4406	-0.3709	-0.522	0.01405	-0.5532
Iron	-0.1881	0.0494	0.2741	-0.4453	-0.0031

TABLE:4.2 Correlation coefficient matrix showing relation between essential parameter without adding surfactant

	TDS	Alkalinity	Calcium	Magnesium	copper	Nickel	Iron
TDS	1						
Alkalinity	-0.5058	1					
Calcium	0.4099	0.0339	1				
Magnesium	0.3883	-0.1482	0.5756	1			
Copper	-0.813	0.6049	-0.1993	0.0047	1		
Nickel	-0.3453	-0.4901	-0.6497	-0.4388	0.0624	1	
Iron	0.004	0.6454	0.4334	0.2065	-0.0338	-0.7555	1

TABLE 5.1 Correlation coefficient matrix showing relation between Desirable parameter by adding surfactant

	pH	Conductivity	Total Hardeness	Acidity	Free Co2
pH	1				
Conductivity	0.14872641	1			
Total Hardeness	-0.7359898	-0.1642969	1		
Acidity	-0.3303932	-0.3084041	0.730168946	1	
Free Co2	-0.6278894	-0.115391	0.733365787	0.5097713	1
TDS	0.02053356	0.60481053	0.267140486	-0.031725	0.418538
Alkalinity	-0.0966471	-0.4383792	-0.033664467	0.2990963	0.098374
Calcium	-0.636051	-0.5347679	0.797895447	0.7710345	0.729271
Magnesium	-0.7089752	-0.0439198	0.983849643	0.6624066	0.677164
Copper	-0.3493553	0.04774801	0.246004017	0.4752129	0.176001
Nickel	0.59276877	0.11210152	-0.530008955	-0.372187	-0.54751
Iron	-0.5043795	-0.2937492	0.436076638	0.4067317	0.347513

TABLE 5.2 Correlation coefficient matrix showing relation between essential parameter by adding surfactant

	TDS	Alkalinity	Calcium	Magnesium	copper	Nickel	Iron
TDS	1						
Alkalinity	-0.3772069	1					
Calcium	0.00683681	0.18217696	1				
Magnesium	0.32175997	-0.0967209	0.677141467	1			
Copper	-0.3430728	0.58420062	0.104364605	0.2682451	1		

Nickel	*-0.3055884*	*-0.5489724*	*-0.542689617*	*-0.48314*	*-0.25099*	*1*	
Iron	*0.08857751*	*0.60016441*	*0.580046164*	*0.3580658*	*0.182483*	*-0.94011*	*1*

IV. RESULT AND DISCUSSIONS

A. pH

The pH varied from7.2 maximum at sampling site 1 and 6.1 at sampling site 8 without adding surfactant. With the addition of surfactant the pH varied from7.6 to 6.49 at sampling sites no 3 and 4 respectively.

B. Conductance

The Conductance varied from maximum 770 µmho/cm at sampling site 3.to minimum of 590 at sampling site no 1 without surfactant whereas the data exceeded to 920µmho/cm at sampling site no 2 to 630 minimum at sampling site no 1 with the addition of surfactant. Almost all the water samples exceeded the permissible limit (300 µmho/cm) due to the high concentration of Ionic constituents present in the water bodies under study and reflect the contributions from salinity intuition as Well as pollution by industrial wastes. The Electrical Conductivity is due to mainly the dissolved ions such as Bicarbonates, Chlorides, Sodium, Potassium, Magnesium and Sulphate.

C. Total Hardness

The Total Hardness varied from maximum558 mg/l at sampling site no 8 to a minimum of 252.3 at sampling site no 2 without addition of surfactant. With the addition of surfactant the data decreased to 495 at sampling site no 8 maximum to 214.5 at sampling site no 2 minimum.

D. Alkalinity

The data for Alkalinity without the addition of surfactant varied from maximum 446 mg/l to 112.29 mg/l at sampling site no 7 and 3 respectively whereas on addition of surfactant the data varied from468mg/l to 123 mg/l at sampling site no. 7 and 3.it clearly indicates that addition of surfactant has enhanced the alkalinity of the waste water sample

E. Total Dissolved Solids

The Total Dissolved Solids varied from maximum 430.23 mg/l at sampling site no.3 to a minimum of 306.05 at sampling site no.1 without the addition of surfactant .on adding the surfactant the TDS varied form 431.56 mg/l maximum to 327 mg/l to minimum at sampling site no.3 and 1. The Total Dissolved Solids were found due to the presence of various kinds of waste originated from various industries. Also organic substances, which are generally found in polluted water, may also contribute to the Dissolved Solids. Concentrations of Dissolved Solids, Suspended Solids are important parameter in water quality management. Sodium lauryl sulphate responded to TDS and hence enhanced the TDS of water.

F. Calcium

The Calcium varied from maximum 221 mg/l at sampling site 8 without adding surfactant to minimum 161 mg/l at sampling site no.5, whereas with the addition of surfactant the calcium concentration varied from maximum 201mg/l at sampling site8 to minimum 133.2 mg/l at sampling site no.2.

G. Magnesium

The Magnesium varied from maximum 337 mg/l at sampling site 8 without the addition of surfactant to minimum 86 mg/l at sampling site 1, whereas on adding surfactant the Mg varied from maximum 294 mg/l at sampling site 8 to minimum of 75 mg/l at sampling site 1. Magnesium is moderately toxic element, if its concentration in drinking water is high. If high concentration of Mg is combined with Sulphate, laxative effect results

H. Copper

The copper varied from maximum 8.1 mg/l at sampling site 5 to minimum 1.6 mg/l at sampling site 3, whereas on adding the surfactant the Cu varied from maximum 5.29 mg/l at sampling site 7 to minimum 1.1 mg/l at sampling site 3.

I. Nickel

The Nickel varied from maximum .78 mg/l at sampling site 2 without adding surfactant to minimum .13 mg/l at sampling site no.4, whereas with the addition of surfactant the Nickel concentration varied from maximum .28 mg/l at sampling site1 to minimum .1 mg/l at sampling site no.4 and 6.

J. Iron

The Iron varied from maximum 966 mg/l at sampling site 7 to minimum 121 mg/l at sampling site 1 without the addition of surfactant, whereas on adding surfactant it varied from maximum 728mg/l at sampling site 7 to minimum 98 mg/l at sampling site 1. The limit on Iron in water is based on aesthetic and taste consideration rather than its physiological effects

V. CONCLUSION

The general physical and chemical analyses of the effluents are given in Table 6 . The pH values of all the effluents were alkaline. The waste water from the industries when released continuously to the cultivation land, soil will render itself unfit for further cultivation as most of our soils are already alkaline. However, the buffering capacity of soil tends to bring homeostasis and lower the pH of the effluents applied according to pH of the soil (Nyle, 1984). According to (David et al., 1996), the optimum pH of irrigation water ranges from 6.5 to 8.5, while the permissible limit is 9. On addition of anionic surfactant the pH was found to increase.

Conductivity also showed enhancement on addition of surfactant. As without the surfactant the waste water gives the conductance of total dissolved solids and after the addition of surfactant the anionic surfactant gets dissociated into ions and thus the conductivity increases and as we know that the electrical current is transported by the ions in solution, the conductivity increases as the concentration of ions increases. Thus conductivity increases as water dissolved ionic species. Wastewaters from iron and steel industry have the highest amount of heavy metals rendering them most hazardous for soil, plant and other organisms including human beings.

The work presented here only studied the chemical quality of the industrial effluents; with the help of surfactant. The anionic surfactant used is sodium lauryl sulphate. Surfactant is added to the polluted aqueous solution containing metal ions and/or organic solutes. The surfactant forms micelles which are charged spherical aggregates containing 50 to 150 surfactant molecules at a concentration higher than its critical micelle concentration (cmc). The metal ions are adsorbed on the surface of the oppositely charged micelles by electrostatic attraction. This method has the following advantages: simple operation; environmentally safer; low-energy requirement; high removal efficiency; easy to recover metal ions; less expensive; separation can be carried out at room temperature.

REFERENCES

[1] APHA (1989)," Standard Methods for Examination of Water and Wastewaters", 17thed. American Public Health Association, Washington DC, USA.
[2] APHA, AWWA, WPCF, (1995),"Standard Methods for the Examination of Water and Wastewater", 19th ed. American Public Health Association, Washington, DC.
[3] APHA,(1998),"Standard Methods for the Examination of Water and Wastewater". APHA-AWWA-WPCF.Washington D.C.
[4] Altman and Parizek, (1995),"Dilution of nonpoint source nitrate in ground water". J. Environ. Quality: 24:707- 717.
[5] Adekunle, A. S (2009),"Effects of Industrial Effluent on Quality of Well Water within Asa Dam Industrial Estate", Ilorin, Nigeria. Nature and Science 2009:7(1).
[6] Ademoroti C.M.A (1996). "Standard methods for water and effluent analysis "Environment microbiology and medical science on bioremediation. 1st edition, chapter 2, 20-50.
[7] Ali K, Javid MA, Javid M,(1996)," Pollution and Industrial Waste". 6th National Congress Soil Sci; Lahore.. pp. 122–131.
[8] American Public Health AssociatioN (1999), American Water Works Association, Water Environment Federation.
[9] APHA-AWWA-WEF,(1992)," Standard Methods for the Examination of Water and Wastewater", , 18th Edition, , Method 4500-H.
[10] Bland, J. (1996),"Contemporary Nutrition". J & B Associates.
[11] Cohen JM et al. "Taste threshold concentrations of metals in drinking water". Journal of the American
[12] Dean J. G., Bosqui F. L. and Lanouette K. H. (1972)," Removing heavy metals from wastewater". Environ. Sci.Technol. 6, 518±522.
[13] Deuzuane J (1979),"Handbook of drinking water quality". Indiana Univ.Press pp. 3-17.
[14] Dee AK (1989),"Environmental chemistry". Second ed. pp. 164-272.
[15] Davies, S. and A. Stewart.,(1997), Nutritional Medicine. Pan
[16] David HFL, Bela GL, Paul AB (1996)," Environmental Engineers Handbook". 2nd Ed. New York: Lewis Publishers.
[17] EPA (1979) March,"Methods for Chemical Analysis of Water and Wastes", U.S. -600/4-79-020.
[18] Goldface Dr., (1999). "Water Laws and Water Law Administration."National Water Resources Institute, Kaduna, Nigeria, pp 56-57.
[19] Gupta v, et al, (2001)," process development for the removal of lead and chromium from aqueous solutions using red mud an aluminum industry waste". Wat. Res. Vol. 35, No. 5, 1125±1134, 2001,# Elsevier Science Ltd.
[20] Ghafoor A, Rauf A, Arif M, Muzaffar W.(1994),"Chemical composition of effluents from different industries of the Faisalabad city". Pak J Agric Res Sci.; 31:367–369.
[21] Holden, S., Hudson, K., Tilman, J. & D. Wolf, (2003),"The Ultimate Guide to Health from Nature". Astrologic Publication.
[22] I.S.I. (1982), "Tolerance limits for industrial pollutants pre-scribed by Indian Standards Institution", IA: 2490 (Part II), I.S.I. (1991) Drinking water specification, IS: 10500.
[23] Jinwal, A, Dixit S, (2008)," Pre and post monsoon variation in physio-chemical characteristic in groundwater quality in Bhopal", India. Asian j. Exp. Sci.: 22 (3).
[24] Irshad A, Ali S, Jan MR.(1997) NSMTCC'97 on" Environment Pollution. Islamabad", Pakistan:. Physico-Chemical Studies of Industrial Pollutants.
[25] Kamal D. et al (2007),"Study on the physicochemical properties of water of mouri river,Khulna,Bangladesh",Pakistan Journal of biological science 10(5):710-717-
[26] Masutani G., Stenstrom M.K.A review of surface tension measuring techniques,surfactants, and their implications for oxygen transfer in wastewater treatment plants.
[27] Nyle CB(1984)," The Nature and Properties of Soils". NY: Macmillan Pub. Co;
[28] Pressman, A. and S. Buff,(2000),"The Complete Idiot's Guide to Vitamins and Minerals". (2nd Ed.) Alpha Books.
[29] Rajappa, B., Manjappa, S & Puttaiah, E.T. (2010)," Monitoring of heavy metal concentration in groundwater of Hakinaka Taluk, India".Contemporary Engineering Sciences, 3(4):183-190.
[30] Rao, Sudhkar M, Mamatha, P,(2004),"Water quality in sustainable water management", Current science.:87.

[31] Saravanakumar K.,Ranjith kumar R.(2011),"Analysis of water quality of groundwater near Ambattur industrial area,Tamil nadu,india,indian journal of science and technology,vol.4 (5):660-662.
[32] Soothill, R.(1996),"The Choice Guide to Vitamins and Minerals". A Choice Book Publication.
[33] Sullivan, K. (2002), "Vitamins and Minerals": A Practical Approach to a Health Diet and Safe Supplementation. Harper Collins.
[34] WHO (2004) International standards of drinking water. World Health Organization, Geneva.55-79.
[35] Weber Jr. W. J. (1972)," Physicochemical processes for water quality control". Wiley Interscience, New York.