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A REVIEW: PHYSIOCHEMICAL ANALYSIS OF INDUSTRIAL WASTE WATER

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ABSTRACT

People on globe are under tremendous threat due to undesired changes in the physical, chemical and biological characteristics of air, water and soil. Due to increased human population, industrialization, use of fertilizers and man-made activity water is highly polluted with different harmful contaminants. Natural water contaminates due to weathering of rocks and leaching of soils, mining processing etc. It is necessary that the quality of drinking water should be checked at regular time interval, because due to use of contaminated drinking water, human population suffers from varied of water borne diseases. The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. It is necessary to know details about different physico-chemical parameters such as color, Odor, temperature, acidity, Electrical Conductivity, pH, sulphate, chloride, Total Hardness, total Dissolved Solid, DO, BOD, COD, alkalinity used for testing of water quality. Heavy metals such as Pb, Cu, Zn, Fe, Hg etc. are of special concern because they produce water or chronic poisoning in aquatic animals. Some water analysis reports with physic-chemical parameters have been given for the exploring parameter study. Guidelines of different physic-chemical parameters also have been given for comparing the value of real water sample.

KEYWORDS: Water, Physico - chemical, Parameters, Hardness, BOD, Heavy metals

Water is one of the most important and abundant compounds of the ecosystem. All living organisms on the earth need water for their survival and growth. As of now only earth is the planet having about 70 % of water. But due to increased human population, industrialization, use of fertilizers in the agriculture and man-made activity it is highly polluted with different harmful contaminants. Therefore it is necessary that the quality of drinking water should be checked at regular time interval, because due to use of contaminated drinking water, human population suffers from variety of water borne diseases. It is difficult to understand the biological phenomenon fully because the chemistry of water reveals much about the metabolism of the ecosystem and explain the general hydro - biological relationship (Basavaraja Simpi *et al.*, 2011). Effluents are wastes produced from industries and they vary depending on the human activities that produce them. Production of these wastes is an integral part of industrial activities but unfortunately our inability to anticipate or predict the types and magnitude of undesired consequences of unbridled release of effluents in our environment, coupled with the growth of industrialization have resulted in massive and destructive operations in our ecosystems. Although industrial processes are desirable, at the same time, the serious and irreversible damage done to the environment through their apparently innocuous discharges of effluents are unquantifiable. Until now, effluents are discharged into rivers, estuaries, lagoons or the sea without treatment by most of the industries. However, despite the treatment being employed by some industries, it is still impossible to remove all undesirable properties from effluents.

The availability of good quality water is an indispensable feature for preventing diseases and improving quality of life. Natural water contains different types of impurities are introduced in to aquatic system by different ways such as weathering of rocks and leaching of soils, dissolution of aerosol particles from the atmosphere and from several human activities, including mining, processing and the use of metal based materials (Adeyeye 1994, Asaolu 1997). The increased use of metal-based fertilizer in agricultural revolution of the government could result in continued rise in concentration of metal pollutions in fresh water reservoir due to the water run-off. Also fecal pollution of drinking water causes water born disease which has led to the death of millions of people. (Adefemi and Awokunmi, 2010).

Industrial development (either new or existing industry expansion) results in the generation of industrial effluents, if untreated results in water, sediment and soil pollution. The excessive amount of heavy metals such as Pb, Cr and Fe, from industrial processes are of special concern because they produce water or chronic poisoning in aquatic animals. High levels of pollutants mainly organic matter in river water causes an increase in biological oxygen demand (Kulkarni 1997), chemical oxygen demand, total dissolved solids, total suspended solids and fecal coli form make water unsuitable for drinking, irrigation or any other use (Hari 1994). There

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are trends in developing countries to use sewage effluent as fertilizer has gained much importance as it is considered a source of organic matter and plant nutrients and serves as good fertilizer (Riordan 1983). As farmers are mainly interested in general benefits, like increased agriculture production, low cost water source, effective way of effluent disposal, source of nutrients, organic matter etc, they are not well aware of its harmful effects of heavy metal contamination of soils, crops and quality problems related to health. Recent studies had proven that long term use of this sewage effluent for irrigation contaminates soil and crops to such an extent that it becomes toxic to plants and causes deterioration of soil (Quinn 1978, Hemkes 1980). This contains considerable amount of potentially harmful substances including soluble salts and heavy metals like Fe^2+, Cu^2+, Zn^2+, Mn^2+, Ni^2+, Pb^2+. Additions of these heavy metals are undesirable.

Physico- Chemical Parameters

It is very essential and important to test the water before it is used for drinking, domestic, agricultural or industrial purpose. Water must be tested with different physical parameters. Selection of parameters for testing of water solely depends upon for what purpose we are going to use that water and what extent we need its quality and purity. Water does contains different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities. Some physical test should be performed for testing of its physical appearance such as temperature, color, odour, pH, turbidity, TDS etc, For obtaining more and more quality and purity of water, it should be tested for its trace metal, heavy metal contents and organic i.e. pesticide residue. It is obvious that drinking water should pass these entire tests and it should contain required amount of mineral level. Only in the developed countries all these criterias are strictly monitored. Due to very low concentration of heavy metal and organic pesticide impurities present in water it needs highly sophisticated analytical instruments and well trained manpower. Following different physic chemical parameters are tested regularly for monitoring quality of water.

Temperature

Temperature is basically important for its effect on certain chemical and biological radiations taking place in water. It depends upon season, time sampling etc. The water temperature plays an important role in influencing plants. It is measured by the standard thermometer in the field itself. The water discharged from industries, which has generally higher temperature, affects the land adversely. The temperature of the discharge should not exceed 35°C since high temperature may produce softening of bituminous joints and may be detrimental to the pipe material itself. The rise in temperature accelerated the chemical reaction in oxygen. Beruch *et.al*., (1993), recorded the temperature 18% degree of the Gelabil in Assam.

pH

pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH is positively correlated with electrical conductance and total alkalinity(Gupta 2009). The reduced rate of photosynthetic activity the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH, the low oxygen values coincided with high temperature during the summer month. Various factors bring about changes the pH of water. The higher pH values observed suggests that carbon dioxide, carbonate-bicarbonate equilibrium is affected more due to change in physico-chemical condition (Karanth 1987).

EC (Electrical Conductivity)

Conductivity shows significant correlation with ten parameters such as temperature, pH value, alkalinity, total hardness, calcium, total solids, total dissolved solids, chemical oxygen demand, chloride and iron concentration of water. Navneet Kumar *et al.* (2010) suggested that the underground drinking water quality of study area can be checked effectively by controlling conductivity of water and this may also be applied to water quality management of other study areas. It is measured with the help of EC meter which measures the resistance offered by the water between two platinized electrodes. The instrument is standardized with known values of conductance observed with standard KCl solution.

Carbon Dioxide

Carbon dioxide is the end product of organic carbon degradation in almost all aquatic environments and its variation is often a measure of net ecosystem metabolism (Smith 1997, 1993, Hopkinson 1985). Therefore, in aquatic biogeochemical studies, it is desirable to measure parameters that define the carbon dioxide system. CO_2 is also the most important green house gas on Earth. Its 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. There are various readily measurable parameters of aquatic carbon dioxide system: such as pH (pCO_2), total dissolved inorganic carbon (DIC) and total alkalinity (TA). Surface water pCO2 can be measured by photometric method (DeGrandpre 1993, Wang, Z 2002) and DIC CO_2 is measured by coulometer or by an infrared CO_2 analyzer (Dickson 1994). Total Alkalinity CO_2 is determined by HCl titration of the water sample to the CO_2 equivalence point (Gran 1952).

Dissolved Oxygen

DO is one of the most important parameter. Its correlation with water body gives direct and indirect information e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc. (Premlata Vikal, 2009). In the progress of summer, dissolved oxygen decreased due to increase in temperature and also due to increased microbial activity (Moss 1972, Morrissette 1978, Kataria, 1996). The high DO in summer is due to increase in temperature and duration of bright sunlight has influence on the % of soluble gases (O^2 & CO^2). During summer the long days and intense sunlight seem to accelerate photosynthesis by phytoplankton, utilizing CO_2 and giving off oxygen. This possibly accounts for the greater qualities of O_2 recorded during summer (Krishnamurthy, 1990). DO in sample is measured titrimetrically by Winkler's method after 5 days incubation at 293 K. The difference in initial and final DO gives the amount of oxygen consumed by the bacteria during this period. This procedure needs special BOD bottles which seal the inside environment from atmospheric oxygen.

Biochemical Oxygen Demand (BOD)

BOD is a measure of organic material contamination in water, specified in mg/L. BOD is the amount of dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of certain inorganic materials (e.g., iron, sulfites). Typically the test for BOD is conducted over a five-day period (Ogunfowokan *et al.,* 2005) (Rashmita Patel *et al*., 2015).

Chemical Oxygen Demand (COD)

COD is another measure of organic material contamination in water specified in mg/L. COD is the amount of dissolved oxygen required to cause chemical oxidation of the organic material in water. Both BOD and COD are key indicators of the environmental health of a surface water supply. They are commonly used in waste water treatment but rarely in general water treatment. (Chaurasia *et al.,* 2011) (Patel *et al*., 2015).

Sulphate

It is measured by nephelometric method in which the concentration of turbidity is measured against the known concentration of synthetically prepared sulphate solution. Barium chloride is used for producing turbidity due to barium sulphate and a mixture of organic substance (Glycerol or Gum acetia) and sodium chloride is used to prevent the settling of turbidity.

Ammonia (Nitrogen)

It is measured spectroscopically at 425 nm radiation by making a colour complex with Nessler's reagent. The conditions of reaction are alkaline and cause severe interference from hardness in water.

Calcium

It is measured by complexometric titration with standard solution of ETDA using Patton's and Reeder's indicator under the pH conditions of more than 12.0. These conditions are achieved by adding a fixed volume of 4N Sodium Hydroxide. The volume of titre (EDTA solution) against the known volume of sample gives the concentration of calcium in the sample.

Magnesium

It is also measured by complexometric titration with standard solution of EDTA using Eriochrome black T as indicator under the buffer conditions of pH 10.0. The buffer solution is made from Ammonium Chloride and Ammonium Hydroxide. The solution resists the pH variations during titration.

Sodium

It is measured with the help of flame photometer. The instrument is standardized with the known concentration of sodium ion (1 to 100 mg/litre). The samples having higher concentration are suitably diluted with distilled water and the dilution factor is applied to the observed values.

Chloride

It is measured by titrating a known volume of sample with standardized silver nitrate solution using potassium chromate solution in water or eosin/fluorescein solution in alcohol as indicator. The latter indicator is an adsorption indicator while the former makes a red colored compound with silver as soon as the chlorides are precipitated from solution.

Most of the physico- chemical parameters are determined by standard methods prescribed by ASTM (2003) and APHA (1985), Trivedy and Goal (1986), Kodarkar (1992).

Some Physico Chemical Analysis Study of Polluted Water Sample In India

Physico chemical parameter study is very important to get exact idea about the quality of water and we can compare results of different physico chemical parameter values with standard values. (Table ,1).

Patel *et al*., 2015 collected Sample of textile industry effluent from south Gujarat Region and analyzed the various physicochemical parameters such as colour, odour, temperature, alkalinity, acidity, chloride, hardness, total dissolved solids(TDS), total suspended solid, pH, DO, COD, BOD using standard procedures. The results of this analysis were compared with the water quality standards of BIS (Bureau of Indian Standard). The study revealed that direct discharge of untreated Textile effluents poses a health risk to several rural communities which rely on the receiving water bodies primarily as their source of domestic water.

Manikandan *et al*., (2015) observed that the pollution load of the various textiles industrial effluents vary from time to time depending upon the dyes, impurities on the fabrics and other processing chemicals used for the dyeing. Five sampling points were identified from textile industries of Tirupur city, India (E1 to E5) and the study was carried out on the basis of field analysis and characterization studies. The major pollution indicating parameters like COD, BOD, TDS, SS, alkalinity, pH, total hardness, and sulfate and chloride levels were analyzed. The effluent was highly turbid and colored with average organic and inorganic loading. BOD5/COD ratios ranged from 0.2-0.5 indicating that the effluent contained a large proportion of non-biodegradable organic matter. The effluent also contained high concentration of sulfate, chloride, calcium and magnesium, which are responsible for higher total hardness of effluent. Sample E4 shows high total hardness, alkalinity, pH and conductivity compared to all other effluents and needed much attention to find a suitable technology for the treatment. The effluents from the study area containing pollution indicating parameters considerably higher than the standards stipulated by the governmental authorities.

Nirgude et al., 2013 investigated physicochemical characteristics of some industrial effluents from various industries in and around Vapi Industrial Area for five months intervals during Sep 2008-Jan 2009, however in this paper data is presented for the month of Jan 2009. In all 17 parameters were studied which includes Colour, temperature, pH, electrical conductivity, TDS, TSS, BOD, COD, Chloride, sulphate, Nitrate, Phosphate, Calcium, Magnesium, Sodium and Potassium ions. The pollution levels from these industries were found to be very high and alarming and hence proper care must be taken for the treatment of these effluents before they are released to the sewage. Many big industries have their own effluent treatment plants, but small scale industries are not following the guidelines prescribed for the industrial effluents. The study has shown that almost all the parameters are on the higher levels than the prescribed limit and hence proper treatment methods are needed.

Asaithambi *et al.,* 2011 studied the removal of organic compounds from a simulated sugar industrial effluent through the electrochemical oxidation technique. Effect of various experimental parameters such as current density, concentration of electrolyte and flow rate in a batch electrochemical reactor was studied on the percentage of COD removal and power consumption. The electrochemical reactor performance was analyzed based on with and without recirculation of the effluent having constant inter-electrodes distance. It was found that the percentage removal of COD increased with the increase of electrolyte concentration and current density. The maximum percentage removal of COD was achieved at 80.74% at a current density of 5 A/dm^2 and 5 g/L of electrolyte concentration in the batch electrochemical reactor. The recirculation electrochemical reactor system parameters like current density, concentration of COD and flow rate were optimized using response surface methodology, while COD removal percents were maximized and power consumption minimized. It has been observed that the predicted values are in good agreement with the experimental data with a correlation coefficient of 0.9888.

Noorjahan, 2014. analyzed Physicochemical parameters like colour, odour, pH, electrical Conductivity (EC),Total suspended solids (TSS), Total dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), chromium and copper of untreated tannery effluent along with the degradation of the effluents using native and non-native bacteria. The results revealed that untreated tannery effluent was black in colour with offensive odour. pH was alkaline with high organic load such as EC, TSS, TDS, BOD and COD which were higher than the permissible since the effluent had high organic load, microbes (bacteria) present within the effluent was identified and isolated. Occurrence of 4 species of bacteria namely *Escherichia coli*, *Klebsiella* sp., *Pseudomonas* sp. and *Staphylococcus aureus was* observed . The presence of bacteria indicates the pollution status of the untreated tannery effluent suggesting that it should be treated before its disposal using the biological method particularly native and non-native bacteria for comparing their degrading efficiency. The results of the degradation study shows that native bacteria *E. coli* was found to be very much successful in reduction of toxic substances at the percentage range of 54-91% whereas non-native *Bacillus* sp showed reduction percentage range of 56-95% and the bio-treated water can be reused for the agricultural and aqua cultural purposes.

Chandrakar *et al*., 2014 observed that Peri-urban cultivated areas of many cities in India are being irrigated from municipal and/or industrial sewage water since long. The status of heavy metals, microbes diversity and fungal tolerance to heavy metals in the Water sample collected from two zone of Bhilai (Talpuri and Nehru Park) was checked. There was a marked differentiation among the water for various heavy metals (Pb, Cr, Zn, Cu, Cd, and Ni etc) and fungal diversity. Seven fungal species were found in this water. The most common fungal strains viz., *Aspergillus* sp, *Fusarium* sp, *Sarcinnella* sp. and Cladosporium sp. were tested for tolerance against the heavy metals Pb and Cr. The degree of tolerance was measured by concentration of heavy metals absorbed by fungal strains. Among the isolated fungal strains of both zones *Fusarium* sp and *Cladosporium* sp. was most tolerant against the tested heavy metals. It absorbed high amount of heavy metals followed by *Aspergillus* sp, and *Sarcinnella* sp. Thus the heavy metals absorbed by fungus *Sarcinnella* sp. has shown a high absorbance concentration, which makes it attractive potential candidate for further investigation regarding its ability to remove metals from contaminated water.

Chandrakar *et al.,* (2012) collected Water sample from two zone of Jabalpur (Civil Line and Adhartal) to investigate the status of heavy metals, microbes diversity and fungal tolerance to heavy metals. There was marked differentiation among the water for various heavy metals (Zn, Cu, Cd, and Ni etc) and fungal diversity. Seven fungal species were found in this water. The most common fungal strains viz., *Aspergillus* sp, *Fusarium* sp, *Sarcinnella* sp. and *Cladosporium* sp. were tested for tolerance against the heavy metals Zn and Cu. The degree of tolerance was measured by concentration of heavy metals absorb by fungal strains. Among the isolated fungal strains of both zones *Fusarium* sp and *Cladosporium* sp. was most tolerant against the tested heavy metals. It absorb high amount of heavy metals followed by *Aspergillus* sp, and *Sarcinnella* sp.(Table 2).

Sharma *et al.,* (2014) investigate the Physico-Chemical characteristics of the samples are present in table and the comparison is carried out with the WHO guidelines. In the present study only the temperature, pH and dissolved oxygen of water samples are ranged between or quite close to the range of WHO. The Bore well water from Lingojijudan, have higher values of Total Dissolved Solid, Salinity, Dissolved Oxygen, Total Hardness, Turbidity, Chloride, Sulphate, Phosphate Fluoride and Arsenic than WHO values. So the water samples which is collected from Lingojijudan, Nalgonda district, Andhra Pradesh cannot be used as drinking water because the required amount of Physico-Chemical parameters are not within the range.

Sharma *et al*., (2017) studied that Water is a chemical compound with the chemical formula H_2O. Water molecule contains one oxygen and two hydrogen atoms connected by covalent bonds. Water is a liquid at standard ambient temperature and pressure, but it often co-exists on Earth with its solid state, ice, and gaseous state. Ground water pollution is a type of pollution which occurs when ground water becomes contaminated. Water have many Physical and Chemical characteristics like pH, Temperature, Alkalinity, Acidity, Hardness, Chorine, Phosphate, Nitrate, Nitrite, Arsenic and Fluoride There are several processes to measure to Physico-chemical characteristics likeTitrimetric method, Spectrophotomitric method etc.

Table 1: Different analytical water quality parameters with their analytical technique and guideline values as per WHO and Indian standard

S. No	Parameter	Technique used	WHO standard	Indian Standard	EPA guidelines
1	Temperature	Thermometer	-	-	-
2	Color	Visual / color kit	-	5 Hazen units	-
3	Odour	Physiological sense	Acceptable	Acceptable	-
4	Electrical conductivity	Conductivity meter / Water analysis kit	-	-	2500 us/cm
5	pH	pH meter	6.5 – 9.5	6.5 – 9.5	6.5 – 9.5
6	Dissolved oxygen	Redox titration	-	-	-
7	Total Hardness	Complexometric titration	200 ppm	300 ppm	< 200 ppm
8	Alkalinity	Acid – Base titration	-	200 ppm	-
9	Acidity	Acid – Base titration	-	-	-
10	Ammonia	UV Visible Spectrophotometer	0.3 ppm	0.5 ppm	0.5 ppm
11	Bi carbonate	Titration	-	-	-
12	Biochemical Oxygen Demand (B.O.D.)	Incubation followed by titration	6	30	5
13	Carbonate	Titration	-	-	-
14	Chemical Oxygen Demand (C.O.D.)	C.O.D. digester	10	-	40
15	Chloride	Argentometric titration	250 ppm	250 ppm	250 ppm
16	Magnesium	Complexometric titration	150 ppm	30 ppm	
17	Nitrate	UV Visible Spectrophotometer	45 ppm	45 ppm	50 mg/l
18	Nitrite	UV Visible Spectrophotometer	3 ppm	45 ppm	0.5 mg/l
19	Potassium	Flame Photometer	-	-	-
20	Sodium	Flame Photometer	200 ppm	180 ppm	200 ppm
21	Sulphate	Nephelometer / Turbidimeter	250 ppm	200 ppm	250 ppm

Ref.:- [WHO, USEPA, Indian Standard, National Primary Drinking Water Regulations, Drinking Water Contaminants US EPA]

Table 2: Different analytical water quality parameters used for testing of quality of water and their sourse of occurance and potential health effects with USEPA guidelines

Sr. No.	Parameter	Source of occurrence	Potential health effect
01	Turbidity	Soil runoff	Higher level of turbidity are associated with disease causing bacteria's.
02	Color	Due to presence of dissolved salts	-
03	Odor	Due to biological degradation.	Bad odor unpleasant
04	Electrical conductivity	Due to different dissolved solids.	Conductivity due to ionizable ions. High conductivity increases corrosive nature of water.
05	pH	pH is changed due to different dissolved gases and solids.	Affects mucous membrane; bitter taste; corrosion
06	Dissolved oxygen	Presence due to dissolved oxygen.	D. O. corrode water lines, boilers and heat exchangers, at low level marine animals cannot survive.
07	Total Hardness	Presence of calcium (Ca_2+) and magnesium	Poor lathering with soap; deterioration of the

		(Mg^{2}+) ions in a water supply**.** It is expressed. Hardness minerals exist to some degree in every water supply.	quality of clothes; scale forming
08	Total Alkalinity	Due to dissolved gases (CO_2)	Embrittlement of boiler steel. Boiled rice turns yellowish
09	TDS	Presence all dissolved salts	Undesirable taste; gastro-intestinal irritation; corrosion or incrustation
10	Calcium	Precipitate soaps, anionic	Interference in dyeing, textile,
11	Magnesium	surfactants, anionic emulsifiers,	paper industry etc.
12	Ammonia	Due to dissolved gases and degradation of organics	Corrosion of Cu and Zn alloys by formation of complex ions.
13	Barium	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	Increase in blood pressure
14	Biochemical Oxygen Demand (B.O.D.)	Organic material contamination in water	High BOD decreases level of dissolved oxygen.
15	Carbonate	Due to dissolution of CO_2	Product imbalance Unsatisfactory production Short product life
16	Chloride	Water additive used to control microbes, disinfect.	Eye/nose irritation; stomach discomfort. Increase corrosive character of water.
17	Nitrate	Runoff from fertilizer use; leaking from septic tanks, sewage; erosion of natural deposits	Effect on Infants below the age of six months Symptoms include shortness of breath and blue-baby syndrome.
18	Phosphate	-	stimulate microbial growth, Rancidity Mold growth
19	Sodium	Natural component of water	-
20	Sulphate	Due to dissolved Ca/Mg/Fe sulphates	Taste affected; gastro-intestinal irritation. Calcium sulphate scale.

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