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Assessment of Water Quality in Rivers and Lakes With Respect to Heavy Metals and General Water Quality Parameters: A Review

Chemistry

KEYWORDS : Health risk assessment,Heavy metals, Universal water quality index, physicochemical parameters, River and Lake.

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ABSTRACT

Rivers and lakes are the main sources of water to public in the cities and villages either by adequate treatment or by direct consumption from the source. But the quality of water bodies has now deteriorated due to urbanization, industrialization, farming and other anthropogenic activities; this is of a great concern because of importance of water to our lives. Water pollution is on the high rise globally and results in health complications and deaths due to consumption of polluted water. Water quality assessment and possible classification encompasses critical analysis and frequent monitoring of chemical, physical and biological parameters that affects aquatic organisms and humans. Heavy metals including Lead, Arsenic, Cadmium, Copper and Zinc may be monitored due to their high toxicity even at low concentrations. Other parameters of interest includepH, dissolve oxygen, alkalinity, biochemical oxygen demand,electrical conductivity, chemical oxygendemand, and nitrates.

1.0 INTRODUCTION

Access to safe and potable drinking water has become a global challenge to about 1 billion out of the 6 billion people on earth (TWAS, 2002). About 80 countries of the world have shortage of portable water which directly affects their health, economy and general well-being (WHO, 2000). The health effects include various types of water borne diseases which kill an average of more than 6 million children each year (TWAS, 2002). About 70% of the earth's surface is covered by salty water. Fresh water covers only 3% of the earth surface.Aquatic environment has been the receiving end of various types of contaminants, ranging from industrial effluent discharge to house hold wastes, these results in contamination of lakes and river waters which account for only one percent of all water on earth. Heavy metals are one of the common pollutants (Ali et al., 2013) and their release to the environment causes a serious ecological threat through bioaccumulation in food chain (Segura et al., 2006), and increase in concentration of the toxic metals beyond upper permissible limit of the standard results in loss of water quality making water unfit for human consumption, farming and recreational activities (Zhang et al., 2009). Studies on heavy metal contamination of river water and its impact on animals and humans have been conducted by several researchers (S. M. Sakan et al., 2009; O.I. Davutluglu et al., 2011 and A. A. Otitoloju et al., 2003).Cadmiumand some other heavy metals are nonessentialbiologically, and are proven to be toxic at low concentrations, while some elements are required for normal body functionsegzinc, copper, iron, iodine, nickel, manganese, , molybdenum, selenium, andcobalt (Alemdaroˇglu et al. 2003). Most of these metals are ingested through drinking water,therefore water quality was used to judge and decide on the suitability of water for human consumption and aquatic lives. An effective water monitoring and managementprogrammeshould be based on assessment and evaluation of heavy metals in an aquatic environment (Davide et al., 2003). The concentration of heavy metals in water for drinking purpose should not be higher than the standard acceptable limit values; otherwise, the bioaccumulation and bio magnification of the metals will result in many health complications to humans and other living organisms. Heavy metals toxic effect varies according to the chemical behavior of the metal. Generally, the toxicity of the heavy metals is by forming complexes organic compounds, there by losing their molecular functionsandcharacteristics leading to the death of the effected cells. Physicochemical and biological properties are good indicators of water quality; it encompasses physical assessment such as odor, color, and taste to microbial investigation such as coliform bacteria etc.

The objective of this paper is to review various studies on water quality of rivers and lakes with respect to basic water quality parameters and heavy metal pollutants. Also to discuss the risk assessment associated with heavy metals in water.

2.0 Literature Review

Many lakes were created in Malaysia to meet up with the nations need and demand of water (Sharip and Zakaria, 2008). Studies of lakes showed that the lakes were classified as polluted (Mohkeri, 2002); important water quality parameters exceeded the permitted level set by the Department of Environment (DOE) Malaysia.

Surface water quality assessment of Mallathahalli lakeand Sankey tank , in Bangalore India using water quality index technique, water samples were analyzed comprising of Physicochemical assessment of the water samples where thecations (Fe^{2+},Ca^{2+}, Na^{+}, Mg^{2+}, K^{+}) and anions (F^{-}, SO_4^{2-},HCO_3^{-}, Cl^{-}, PO_4^{3-} ,NO_3^{-}) with general water quality parameters (DO, EC, alkalinity, turbidity, total hardness, TDS, BOD, pH, COD, CO_2, SiO_2, colour) most of the analyzed parameters were found to exceed India water quality standard (P. Ravikumar et al., 2013)

A study investigating the water quality of some ex mining lakes in perak state of Malaysia was carried out for possible use of the lake water as alternative to water supply and compared them to water quality of some of the rivers used for intake of water treatment. The analysis revealed that all the water samples were turbid and containing slightly high concentration of Pb (Kalu U. O. et al., 2014).

A study of Awassalake in Ethiopia reveals that Human impacts on the lake include the release of waste waters. The Awassa textile factory discharges waste waters into the nearby Shallo swamp that drains into TikurWuha River, the only constant inflow to Lake Awassa. The treated waste water from the factory containsPb (7.5 μg l^{-1}), Cd (1.2 μg l^{-1}), Hg (5.1 μg l^{-1}), As (43.2 μg l^{-1}), Se (5.4 μg l^{-1}),Cr (42.6 μg l^{-1}) and other metals. It was observed that the effluents were acutely toxic to fish fry, with a mortality of 64 % in 20 % wastewater solution within 24 h (Gebremariam and Desta2002). Also the largest tannery of Ethiopia is located in Mojo City in the catchment area of Mojo River. Gebremariam and Pearce (2003) measuredSe (19.2 μg l^{-1}),As (14.8 μg l^{-1}) and Cr (141.1 μg l^{-1}) in the tannery effluents.

In the study of water pollution in Megalaya, India, most of the water bodies were coloured from brownish to reddish orange, signifying pollution of the rivers and streams mostly in the mining areas. General physico chemical parameters and other heavy metals that characterize water quality degradation were not within the permissible limit. The dissolved oxygen (DO) was low andpH value was also found to be low between 2-3, high BOD and electrical conductivity, concentrations oftoxic heavy metals and ions of sulphate were also high (Saviour M. N, 2012).

Lake chini was classified under Malaysian interim national water quality standard for recreational activities, as such only body contact is allowed. Conductivity and total solid were found to be within normal range, butchemical oxygen demand, dissolve oxygen and biological oxygen demand were not within acceptable limits (M. S. Othman et al., 2007).

Bukit Merah lake water was analysed and classifiedto detect the level of pollution and suggest the possible treatmentlevelrequired before usage. Parameters analyzed include; dissolved oxygen (DO), ammoniacal nitrogen (NH_3-N), biochemical oxygen demand (BOD),pH, total nitrogen (TN), chemical oxygen demand (COD), suspended solids (SS) and total phosphorus (TP) by in-situ and ex-situ (standard laboratory procedures). Concentrationsof heavy metalssuch aszinc (Zn), nickel (Ni), lead (Pb), cadmium (Cd), iron (Fe), copper (Cu), calcium (Ca) and magnesium (Mg) were analyzed using an Inductively Coupled Plasma Mass Spectrometer (ICP MS). Water quality index (WQI) technique was applied, and considerable level of pollution was detected in all the analyzed parameters. Classification number of Bukit Merah reservoir based on WQI was 75.63 in class III indicating slightly polluted water (Christopher O. A. et al., 2013).

About 11 physical and chemical variables were employed to assess water quality of Pariyej Lake Dist. Kheda – Gujarat, India. The parameters analyzed were BOD, pH, DO, Total hardness, total alkalinity, TDS,Sulphate, Calcium, Nitrate, Chloride,and magnesium. The water quality index was calculated by making reference to the drinking water quality standards which was recommended by the World Health Organization (WHO), Indian Council for Medical Research (ICMR) and Bureau of Indian Standards (BIS) (Thakor F. J. et al., 2011).

General water quality parameters such as dissolved oxygen,water hardness,temperature, total dissolved solid, pH and conductivity and metal concentrations were determined in AmpangHilir Lake, Selangor, Peninsular Malaysia .The metals were Lead, Cadmium, Nickel, Zinc, Copper and Chromium. Comparison was made between concentration of water quality parameters with Malaysia National Water Quality Standard (NWQS), whileconcentrations of the metals analyzed were compared with both Malaysian and international water standards. Based on the results obtained, thewater quality parameters were rated as class II where body contact and other recreational activities are allowed, and suitable for fishing activities. Also,concentrations of the metalswere lower than the international standards, hence toxic effects as a result of exposure to these metals would rarelybe observed and aquatic organisms would rarely be affected. (Said K. S., 2012a)

A study of water quality parameters was carried out in Titiwangsa Lake, Selangor Peninsular Malaysia using hydrolab data sonde 4 and surveyor 4 a water quality multi probe (USA), and the metals were determined using Inductively Coupled Plasma Mass Spectrometer (ICP-MS). Selected parameters analysed were temperature, conductivity, total dissolved solid, dissolved oxygen, pH and water hardness, and the metals were cadmium, chromium, lead, nickel, zinc and copper. The results suggested that water quality was class II suitable only for recreational activities, and metal concentrations were found to be lower than the international standard as such toxic effects of the metals will rarely be observed (Said K. S., 2012b).

Water quality assessment of Dokan Lake in Iraq reveals that most of the parameters were within acceptable limit. The parameters investigated were Dissolved Oxygen,Biochemical Oxygen Demand, pH, Conductivity, Turbidity, Hardness, Nitrate, Sodium, Alkalinity and Nitrite. Among the investigated parameters only electrical conductivity was found to be higher than Iraq and WHO standard (Abdulhameed et al., 2010). The measure of the amount of dissolved cat ions in water is called electrical conductivity, it greatly affect the taste and there has significant impact on user acceptance of water as potable (WHO, 2004; IQS, 2001).

A study of water quality and dissolved heavy metals Cd, Cu, and Zn concentration of the water surface of Kelana Jaya Lakes, kelana jaya municipal park was carried out. Five lakes were analysed for Temperature,pH, Conductivity, DO, ammonia, nitrate, phosphate, dissolvedconcentrations of Zn,Cu, and Cd were used to study the water quality of the lakes. Metal concentrations analyzed were 0.036 to 0.040, 0.027 to 0.047, and 0.011 to 0.015 mg/l respectively for Cd, Cu, and Zn. While dissolve Oxygen was 3.32 to 5.36mg/L, conductivity 0.196 to 0.356 μS/cm , and pH 6.91 to 8.37.According to the national water quality standard (NWQS), the water quality of Kelana Jaya lakes can be considered polluted and deteriorated (A. Isma'il et al., 2005).

Analysis of water samples from Baiyangdian Lake reveals that temperature values varied throughout seasons of the year, summer has temperature range of (29.0-33.2°C) while winter season have lower values of (0.5-2°C). The range of pH values of the water samples ranged from 7.6-8.6, the values falls within the permissible limit of 6-9 allowed by the SEPA for water quality (SEPAC 2002). There is variation in total dissolve solid and electrical conductivityin the annual season cycle,the range in values of 1-230 mg/L and764-2030 mS/m for the TDS and EC respectively. The results also showed that lower concentrations of cations (K, Ca, Na, and Mg) were discovered to be present in a level lowerthan other water bodies in the world (Silva M.A.L. and Rezende C.E. 2002; Kazi T. G. et al., 2009). The concentrations of anions SO_4 and Cl were found to be lower than SEPA limits, the values ranging from 140.1-188.7 mg/Land 108.15-152.23 mg/L respectively. The average nutrient concentrations (TN,NH_4^+ andTP) was also noted to be in higher concentrations than recommended levels,the measured values were 1.18-19.03mg/L, 0.36-15.72mg/L and0.07-1.88 mg/L, respectively.The highest values of and were recorded at Sites 1 and 2 were found to have the highestBOD and COD_{Mn} values of21.38 mg/L and 13.48 mg/L, while at site 10 lowest values were measured as 3.04 mg/L for BOD and 7.50mg/L for COD_{Mn}. Generally high levelsBOD and of COD_{Mn} were found in all the sites under study, values of DO were within the standard permissible limits of Chinese water quality monitoring (Y. Zhao et al., 2012).

Assessment of heavy metals in water samples from Beysehir Lake Turkey showed that heavy metal concetrations was found to be beloe detection limit in some seasons (ppm < 0.028), concntrations of Fe was the highest among the metals analysed ranging from BDL-2.47mg/L , then Mn with concentrations of BDL-0.52 mgl^{-1}, also Zn with concentrations of BDL-0.42 mg/L, Cu BDL-0.10 mg/L , Cu was not detected in the summerbut only in Spring 2004, concentration of Fe, Zn and Mn were the highest in summer 2004, summer 2003, and Autumn 2004 respectively (Selda T. O. 2008).

Investigation of metal levels in Habbaniyya lake Iraq found the concentrations to be 15-86 mgl^{-1} for Zn, 5-50 mgl^{-1} for Cu, 0.3-33.3 mgl^{-1} for Mn. They reported that all metals displayed the highest value during the spring, except Zn during the winter (Al- Saadi et al., 2002).

A study was conducted to assess the water quality of Keenjhar-Lake and its canal leading to Dhabeji treatment and pumping plant. Fourteen samples were collected deterministically from various areas of the lake. Twenty two water quality parameters were measured in all collected samples, including Turbidity, DO, TDS, chloride, alkalinity, hardness, nitrate, sulphate, six heavy metals and coliform bacteria. The physicochemical parameters analyzed were found to be within WHO permissible limits. The samples of water obtained from Kotri and Dhabeji (before pumping station) were of poor quality characterized by the levels of Pb, Cd, Cu and nitrate that exceeded the WHO permissible limits. The highest pH was observed from Dhabeji sample, which also expressed highest levels of Cd, Pb, Cu and Nitrate. It implies that the water from Dhabeji (prior to pumping) is unsafe for human consumption. The next lower quality was that of Kotri, having higher levels of Cd, Pb, Cu and Nitrate (Muhammad A. F. et al., 2013).

Kizilirmak River water analysis in Turkey reveals that mean pH ranged between 8.14 and 8.33, mean salinity measurements ranged between 1.3 and 2.4 ppm, water temperature ranged between 13.9°C and 17.6°C, the mean dissolved oxygen changed according to the temperature, and the values ranged between 5.32 and 7.49 ppm. EC measurement ranged between 128 μmhos and 327 mS.Mn values ranged between min. 1.355 μg/l (in May) and 233.5 μg/l (in February), and mean values in February, May, and August were 81.62, 3.117, and 43 μg/l, respectively. Fe values ranged between min. 51.1 and max. 2819 μg/l in August, and mean values were 386.7, 129.78, and 393.53 μg/l throughout the sampling period Arsenic was measured min. 0.518 μg/l in May and 16.23 in February. Mean values were 13.17, 6.178, and 8.411 μg/l. Cadmium values were measured between 0.063 and 1.477 μg/l (in February), and in August, it was undetectable level. The mean values were 0.440 and 0.287μg/l in February and May sampling (Nuray E. A. and A. M. Tuncer, 2011). The solubility of themetals primarily depends on the pH, dissolvedoxygen, and hardness (Barlas1999). pH ranged between 7.81 and 9.26 and mean dissolved oxygen ranged between 5.32 and 7.49, but in some periods, this value decreased to 0.16 due to the input of heavily polluted wastewaters through the river. An increase in pH generally decreases the solubility of toxic heavy metals (Hellawel1988).

Water quality was determined in thedifferent stretches of the river Sutlej (S1, S2, and S3*)* for a period of 1 year (November 2006 to October 2007). S1 was at Ropar Head Works, S2 at U/S of BudhaNallah at Phillaour, and S3 was D/S of BudhaNallah in district Ludhiana (Punjab). Relatively low values of TDS, turbidity, BOD, total alkalinity, total hardness, chlorides,

Nitrates, and phosphates were recorded at S1 and S2 as compared to S3. Heavy metals like Pb, Zn, Cr, and Ni were detected at S2 and S3. The mean values of these parameters were comparedwith WHO, ICMR, and ISI standards. The water quality index at stations S1, S2, and S3 was 32.84, 51.01, and 132.66, respectively. This clearly indicated that the river water at station S2 andS3was found to be unsafe for human consumption (R. Jinda and C. Sharma, 2011)

Analysis of river Soan in Pakistan shows that Concentration of heavy metals was relatively high during post-monsoon season than pre-monsoon season. Cd at the site4 (0.1 mg L^{-1}); Zn at the site 5 (0.09 mg L^{-1}); Co at the site 2(0.16 mg L–1); Ni at the site 13 (0.42 mg L^{-1}); Cu and Cr at the site3 (0.24, 0.11 mg mg L^{-1}, respectively) and Fe at the site 14 (0.4 mg L^{-1})were higher during post-monsoon season. While Pb at the site 2 (1.1 mg L^{-1}) and Mn at the site 13 (0.16 mg L^{-1}) was higher during pre-monsoon season. The results suggested that may bedue to influx of organic waste during the monsoon season throughsurface runoff might lower pH of water during the post monsoonseason (Kannel et al., 2007). The pH affects biochemical processesas well as it also acts an indicator of water quality and extent ofpollution in the watershed (Kannel et al., 2007). Among differentheavy metals, Cd, Ni and Pb showed higher concentrations thanrecommended for fish or aquatic life or for the purpose of drinkingor recreational activities (SumiyyaNazeer et al., 2014).In Bangladesh, natural levels of Arsenic in ground water were found to be causing harmful effects on the population (Anawara et al., 2002).

3.0 Water Quality Assessments

Water quality assessment entails regular and accurate monitoringof water qualityparameters to safe guard the health of entire aquatic ecosystem and humans. Heavy metals and general Physico chemical parameters are the variables routinely analyzed.

3.1 Heavy Metals

Ingestion of heavy metals through drinking water leads to bioaccumulation and subsequent effect in the body. They are toxic at low concentrations and are not easy metabolized in the system.

3.1.1 Cadmium

Cadmium has a wider use in industries egpaint pigments, PVC plastics, and nickel–cadmium batteries. About 15–50% of cadmium inhalation is absorbed through human respiratory system; while gastro intestinal system absorbed 2–7% of cadmium via ingestion. Cadmium is a metal in sludge-derived fertilizer and present in water sources. Reservoirs of water containing shellfish and tobacco may contain cadmium. The major sources of cadmium pollution are smelting and refining of zinc, lead and copper ores, electroplating, manufacture of cadmium alloys and of pigments and plastic stabilizers, production of nickel–cadmium batteries and welding (ASTDR 1999). Discharges of wastewater from stearate Cd factories also contribute to cadmium pollution (L.T. Lu et al., 2007). Mining and smelting activities have been dispersing cadmium into the environment through air. It is also present in phosphate fertilizers, domestic discharge such as sewage, and many industrial items such aspigments,Ni-Cd batteriesand plastics(ASTDR, 2008).

3.1.2 Arsenic

Acute heavy metal poisoning in adults is commonly caused by arsenic which occur naturally in soil and varies from one region to another. Industrial operations like smelting of lead, copper and zinc, and production of chemicals and glasses. Other sources of arsenic arewood preservatives, paints, rat poisoning and fungicides. Some of the health complications of Arsenic due to its carcinogenic nature include cardiovascular diseases, cancers of bladder, lung, and skin, as well as diabetes prevalence. Arsenic is detrimental to agriculture and its presence inwater for drinking purpose may also affect human immune function (S. M. Shirazi et al., 2011).Arsenic has natural average concentration of 5 mg/kg which is distributed in the Earth's crust, it occurs as a constituent in more than 200 minerals, although it primarily exists as arsenopyrite and as a constituent in several other sulfide minerals. The introduction of arsenic into drinking water can occur as a result of its natural geological presence in local bedrock. Groundwater contamination by arsenic arises from sources of arsenic-rich pyrite, arsenopyrite,iron oxyhydroxide, base metal sulfides, and realgar. Past and current mining activities continue to provide sources of environmental contamination by arsenic. Because gold- and arsenic-bearing minerals coexist, there is a hazard of mobilizing arsenic during gold mining activities. Other important sources of arsenic exposure include coal burning; use of arsenic as pesticides and use of wood preservativecontaining arsenic (H. Grelick, 2008).

3.1.3 Lead

Lead is present in water sources; in river water Lead is mostlyassociated with silver especially in Lead mining catchments. Lead was once commonly used in gasoline (petrol), though its use is now restricted in some countries and is present in water sources. The high concentration of lead in air is mostly found close to lead smelters. There are many sources of lead in air, the major sources being combustion from automobiles and aircrafts, also metals and ores processing plants (EPA, 2012). Pipes and Solders, Gasoline, Paint and many manufacturing industries such as the smelting,lead-acid battery manufacturing, mining, waste incinerating and petroleum industries discharge lead into thesoiland air which is of great health hazard (J. Saccone, 2013). Lead accounts for most of the cases of pediatric heavy metal poisoning. Every year, industry produces about 2.5 million tons of lead throughout the world. Most of this lead is used for batteries. The remainder is used for cable coverings, plumbing, ammunition, and fuel additives.

3.1.4 Zinc
Levels of zinc in the environment especially water is increased to the limit detrimental to human health as a result of industrial activity and other toxic sources. Water, soil and air contain natural concentration of Zinc, but the concentrations are continuously rising due to human activities. During industrial operation like mining, steel processing, waste and coal combustion, much concentrations of Zinc are discharged to the environment. High contamination of soil with zinc was found in areas of Zinc mining, or where industrial discharges are used a fertilizer. About 1 wt% of Zinc content is contained in a tire-tread material; in the course of road transport the exact quantity of tread material lost as a result of abrasion has not been established by Councell et al. 2004. Toxicity as a result of Zinc ingestion is rare and is more likely to occur in adults than in children because it is usually linked to exposure to Zinc fumes in occupation especially mining and metal workers. The frequent intake Zinc supplements can cause copper deficiency, because zinc inhibits absorption of copper in the body.

3.2 Physicochemical Parameters
General properties of water including physical and chemical determine the quality of water, also significantly influence some of the heavy metals availability in water. Parameters of interest are pH, Dissolve Oxygen, Chemical Oxygen Demand, Electrical Conductivity and Biochemical Oxygen Demand.

3.2.1 pH
The acidity or alkalinity of a substance is termed as pH which is mathematically expressed as negative logarithm of Hydrogen ion concentrations. It's important to monitor the pH of natural water as it providevital information directly or indirectly on biological and chemical processes, and it is correlated to many physico chemical parameters and concentrations of heavy metals in solution.

Surface water dissolve Carbon dioxide in air, the quantity of CO_2 and medium temperature determines the pH of the water. The dissolved CO_2 will acidify the water by forming H_2CO_3 that lowers the pH to 6. But the presence of alkaline metals such as potassium raises the pH value to 7thereby increasing the pH as a result of interaction between carbonates and bicarbonates formed from the dissolved and stabilized CO_2.

3.2.2 Dissolve Oxygen
All aquatic organisms needs dissolve oxygen at the required concentration to survive, it is very essential for the metabolism of aquatic organisms. At low and moderate temperature, oxygen tends to be soluble in water forming equilibrium between the dissolved oxygen and atmospheric oxygen. The range of DO of fresh water is from 15 mg/l at 0 ^{0}C to 8mg/l at 25 ^{0}C, and for the concentrations of close to 10 mg/l is for the unpolluted water.

Generally, dissolved oxygen concentrationis a product of activities in the water, higher biological activities lower DO concentration.

In the day light, DO concentration increases due to photosynthetic activity by some aquatic plants, and the concentration drops in the night hours.Organic pollutants in natural water are consumed and degraded by microorganisms, as the microbial decomposition increases more oxygen is consumed to support their metabolic processes; consequently there is more depletion in oxygen concentration near the sediments.Depletion in oxygen makes the water anaerobic, resulting in the death of aquatic organisms.

3.2.3 Biochemical Oxygen Demand
The quantity of oxygen consumed when organic substances decomposed by microorganisms in a litre of water is called Biochemical Oxygen Demand (BOD). Bacteriaand other microorganisms facilitate the decomposition of organic waste. Aerobic bacteria consume the dissolve oxygen in water in the process of decomposition of organic matter like sewage, grass, manure etc there by depriving other aquatic organisms of the available dissolved oxygen for their survival. The amount of oxygen used in the decomposition of the organic matter is called Biological Oxygen Demand (BOD). Therefore large quantity of organic waste in the water body needs more bacterial activity for the decomposition process and results in high BOD level. Presence of phosphates and nitratesin a water body results in high BOD levels. Nitrates and phosphates are major nutrients needed for the rapid plant and algal growth, and plants die quickly when they grow quickly there by depositing more organic waste in the water which is decomposed by the bacteria resulting in high BOD level.High BOD levels results in decreasing dissolved oxygen (DO) levels due to the consumption of the available oxygen in the water by anaerobic bacteria in the decomposition process, this leads to the death of aquatic organisms.

3.2.4 Chemical Oxygen Demand
In the process of decomposition of organic matter and oxidation of inorganic chemicals like phosphite, nitrite, and ammonia, oxygen is needed. The measure of the amount of oxygen needed for the decomposition process is called Chemical oxygen demand (COD).Usually the COD level of polluted water or waste waters from industries are of great concern and monitored. In the determination of COD, a standard laboratory procedure is adopted in which the waste water sample s treated with a small chemical oxidant such as potassium dichromate ($K_2Cr_2O_7$) with boiling sulfuric acid (H_2SO_4) at a specified experimental condition

3.2.5 Electrical Conductivity
The ability of natural water to conduct electric current is called Electrical conductivity (EC).The presence of dissolved salts such as sodium chloride and potassium chloride influenced the conductance of the water samples. The unit of electrical conductivity is micro Siemens per centimeter (µS/cm).

Discharges from domestic and industrial activities, and dissolved salts from natural water runoff are the major sources for the rising Electrical Conductivity in the natural water body. Also in natural waters electrical Conductivity and total dissolved solids (TDS) are related by the equation below;

TDS (mg/L) = EC (mS/cm) * 640

3.3 Universal Water Quality Index
Several water quality indexes were developed from Horton 1965, till date more indexes are developed to suite a particular need and objective. One of the most acceptable indexes is Universal Water Quality Index (UWQI) which was developed in order to device a simpler method for assessing and classification of thesurface water qualityfor drinking purpose. The advantage of UWQI over other existing indices is it reflects appropriate and specific use of drinking water supply rather than general supply, and it was developed by studying the standard of many countries.

Many indices previously developedwere applied based on the water quality standards of the particular country,as such its application is limited only to that particularcountry and this limited their application only within the country it was developed.

The equation below is used to calculate universal water qualityindex;

UWQI = ΣWiIi

where:

Wi = weight for ith parameter
Ii = sub-index for ith parameter

Table 1: Universal Water Quality Index Classification

Rank	WQI Value
Excellent	95-100
Good	75-94
Fair	50-74
Marginal	25-49
Poor	0-24

The index value between 0 to less than 25 represents poor quality, 25 to less than 50 marginal quality, 50 to 75 fair quality, 75 to less than 95 good quality, and above 95 excellent quality.

Table 2: Upper Permissible Limits (Mandatory Standard) of the selected water quality parameters metals in Malaysian drinking water, and WHO standard

Parameter	EQR(2006)	WHO(2008)
pH	8.5	8.5
Electrical Conductivity	1000µS/cm	500 µS/cm
Dissolve Oxygen	7.0 mg/l	5 mg/l
Biological Oxygen Demand	1.0 mg/l	6 mg/l
Chemical Oxygen Demand	25 mg/l	5 mg/l

Table 3: Upper Permissible Limits (Mandatory Standard) of the selected heavy metals in Malaysian drinking water (mg/l), and other world standards

	As	Cd	Pb	Zn
EQR(2006)	0.01	0.003	0.05	3.0
WHO(2004)	0.01	0.003	0.05	-
EC(1998)	0.01	0.005	0.01	0.1
USEPA(2009)	0.01	0.005	0.015	5.0
USEPA(2006)*	0.34	0.002	-	0.12

USEPA (2006)* = Critical values for protection of fresh water Aquatic life

4.0 Health Risk Assessment

Risk assessment involves study of the exposure to heavy metals either by contact with skin or by direct ingestion. The exposure period may take a long period of time and manifest with diseases like cancer, kidney failure, etc.

5.0 Conclusion

1. Generally there are variations in metal concentrations; it increases in hot seasons and decrease in warm seasons. The increase and decrease in metal concentrations can be caused by evaporation in dry season and, by heavy rain and melting snow in the warm season in the water body respectively.
2. Concentrations of heavy metals are higher in lake sediments than the surface water.
3. Low concentrations of heavy metals in river water due to dilution from river tributaries.
4. Variations in concentration of physico chemical parameters affect the concentration of heavy metals in rivers and lakes. A change in pH due to fluctuation in decomposed oxygen and carbonate concentrations will cause an increase in the dissolvability of heavymetals in water.

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