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Water Quality Assessment of Physicochemical Parameters & Heavy Metals Contamination in Surface Water of Jonk River, Kasdol Area, Baloda Bazar, Chhattisgarh

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Abstract: ***Present research work emphasizes the integrated approaches of Physicochemical parameters and heavy metals contamination indices coupled with multivariate statistical analysis to evaluate the range of contamination and health risk from surface water of Jonk river, near Kasdol are of Bolada Bazar District, Longitude21.6569°N, 82.1592°E.In this regards, three sample sites are chosen i.e., site-1 Rajandevri, site-2 Golajhar, & site-3 Chandan, and surface water samples of Jonk river were collected and tasted during monsoon, winter and summer seasons. Parameters of river water were analyzed like PH, Electrical conductance, total dissolved solids (TDS), hardness, Biochemical Oxygen Demands(BOD5), chemical Oxygen Demand(COD) etc.. The heavy metals Viz., Pb, Cd, Zn, Fe, Mn, Cu, Al, Hg, Ni were analyzed[2] through ICP-OES, typical double beam AAS and proposed to compare with the BIS standards for drinking appropriateness. Heavy metal contamination assessment has been proposed to performed by using Heavy metal Pollution Index (HPI), Hazard Index(HI), Heavy Metal Evaluation Index(HEI) and degree of contamination(Cd)[5]. After getting all the indices the mean is compared with the range and undesirable effect above the acceptable limit is found out.***

Keywords: (water quality, Physiochemical parameters, heavy metals contamination, HPI, HEI, River water, pollution assessment, heavy metal)

1. Introduction

Water is an inseparable part of life. Every living being needs water for their survival in this globe. Water is not only used for physical need, but also for various other purposes. In addition, the needs of water are increasing with increasing people. Besides, water is also a crucial raw material for most of the industries; however, it would be detrimental for living beings when polluted. In maximum cases, the effluents discrete from various industries are not treated before disposal to waterway because of the treatment cost, unconsciousness and other various causes (Shaktibala and Bhagat, 2012; Valipour, 2015a, 2015b; Ladwani et al., 2012). As an effect, it is being highly impure with different kinds of damaging contaminants. As a reverie country, the excretion of manufacturing effluents of chhattisgarh is generally run off into the rivers or the canals. Due to this, the water environment approximately us is getting impure and it's getting beyond our control. Though our world contains almost 70% water, the gap between supply and demand is widening and reaching to an alarminglevel. Every conscience person is trying to find out a way to adjust the gap; but, the disposal of municipal and industrial wastes in the water sources is causing major problems regarding the environment and making it fragile (Paul et al., 2012). In result, attempts are been made all around the world to recycle and use again it effectively and efficiently (Franco et al., 2000; Klavins et al., 2000; Rekha and Ambujam, 2012). In the developed countries, there are strict rules for the evacuation of industries pollutants, whereas in developing countries like chhattisgarh, the rules are not followed properly. As a result, most of the rivers in the industrial areas are the final destination of the effluents from the industries. African and Asian countries are experience rapid industrial growth and thus this problem hinders the effort to keep the environment free of contamination (Patil et al., 2012; Animesh and Saxena, 2011).

River water is water affected in quality from various standard parameters set by anthropogenic influence. The liquid waste discharge from marital, industrialized, farming and related sectors containing various kinds of diseases causing contaminants can be found in river water. Industrial waste water contains a broad range of contaminants depending on the production of the industry (Gulp and Gulp, 1971). Various kinds of components may be present in river water. They can be rinsed waters, including residual acids, plating metals and toxic chemicals (Husain et al., 2014). If the effluents are contaminated with toxic metals, it can compromise human health with acute and chronic diseases (Alam et al., 2007; Rahman, et al., 2014). The waste water from environmental fields is flowing through many water sources, as it may contain various organic matter and plant nutrients. Plants can accumulate these metals in their tissues in concentration above the standard levels, which may be a threat to life in a complete cycle (Patil et al., 2012; Amin et al., 2010). The dependence of people on this part of the world is ground and surface water. Industrial and municipal wastes are considered as one of the leading causes to pollute water. The water available for drinking, household and irrigation purpose gets contaminated with heavy metals, metal ions and harmful microorganisms (Gupta et al., 2009;

Gupta et al., 2012). For this reason, the water used for this purpose should be tested with a regular interval being conscious about various parameters of the water. Therefore, the goals of this study were to evaluate the characteristics of waste water and heavy metal contaminations which affect the ecosystem. Further study is needed to evaluate the level of contamination of sediments, aquatic species, plants and animal kingdom to obtain a complete status of the environment in this study area so that proper steps to control the water adulteration by toxic chemicals would be taken.

2. Materials and Methodology

2.1 Study Area

Kasdol is a Block situated in BALODA BAZAR district in Chhattisgarh. Located in rural region of Chhattisgarh, it is one of the 6 blocks of Baloda Bazar district. It is located 114 KM towards East from District head quarters Raipur. 114 KM from State capital Raipur towards west. These study area describe in map 1. The sides name are following side1 is rajadevri, side2 is golajhar and side3 is chandan.

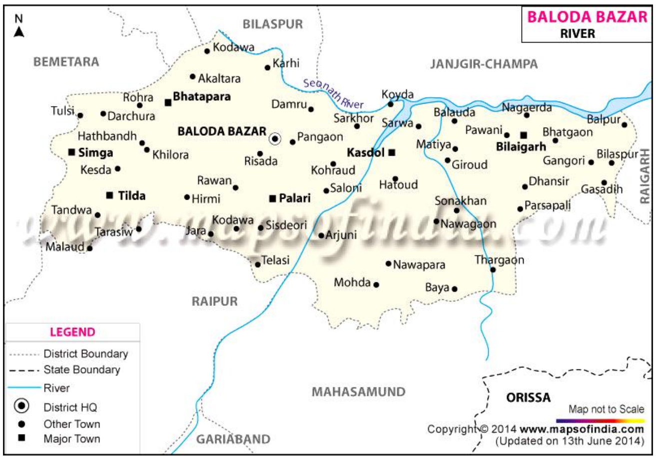

Figure 1: Study Area Map

2.2 Physicochemical characteristics

Inorganic compounds and Organic compounds are the main in charge character for the pollution of water. They determine the measure of hardness, dissolved oxygen, biological oxygen demand,chemical oxygen demand, alkalinity etc. It is also caused by various microbial activities of microorganisms. The parameters such as pH, EC, TDS, hardness, BOD, COD and heavy metals know about the status of pollution in river water were analyzed by standard method (Islam et al., 2016).

Color

Color is a qualitative feature of river water. With the help of its general condition, the river water pollution can be assumed. If the color is dark grey or black, the river water is typically septic, having undergone extensive bacterial decomposition under anaerobic conditions. The color of the sample was compared with the glass comparator and colorless distilled water.

Odor

The determination of odor has become increasingly significant, as the odor may give a hint about the presence of various organic unwanted components in the river water samples. The principal odorous compounds are hydrogen sulphide (the smell of rotten eggs). Other compounds, such as indol, skatol, cadaverin and mercaptan, formed under anaerobic conditions or present in the effluents of pulp and paper mills (hydrogen sulphide, mercaptan, dimethylsulphide etc.), may also cause a rather offensive odor. Odor is measured by successive dilutions of the sample with odor-free water until the odor is no longer detectable.

pH

pH Is considered to be the most important river water parameter. Wastewater pH were less than 6 meaning corrosiveness in nature and those having pH more than 9 will cause some metal ions to precipitate as carbonates or hydroxides. In this study, pH was determined by digital pH meter (model BT-600) brought from BOECO, Germany.

Electrical conductivity

Electrical conductivity showed the significant correlation with various other parameters. The various river water qualities can be checked by calculating electrical conductivity of water and this may also be applied to water quality management of other study area. The electrical conductivity was measured with the help of an electrical conductivity meter (CM-230 meter) which determine the resistance offered by the river water between two Platonized electrodes.

Total dissolved solids

The suspended and dissolved solids in river water are considered as total solids. Solids that are able to settle can be removed by sedimentation. The unit of solids that are able to settle is ppm. Usually, about 60% of the suspended solids in manufacturing river water have solids that are able to settle. This test was done by measuring the volume of solids in one liter of a sample that will settle on the bottom of a conical flask during the subsequent evaporation and drying in oven at specific temperature 103-105°C.

Hardness

Hardness is produced in river water due to various reasons by multivalent metallic cations. The total hardness in water is defined as the summary absorption of calcium and magnesium cations expressed in milligram equivalents per kilogram or microgram equivalents per kilogram. Hardness is determined by the EDTA method by alkaline condition. When EDTA was added as a titrate, Ca and Mg divalent ions formed complexes resulting in a sharp change from wine red to blue which indicates endpoint of the titration (Kaur and Malik, 2012; Islam et al., 2015).

Biological Oxygen Demand (BOD$_5$)

BOD$_5$ test is a valuable test in the analysis of sewage, industrial effluents and grossly polluted water. It is considered as the major characteristic used in stream pollution control. It is generally the amount of dissolved oxygen required for the biochemical decomposition of organic compounds and the oxidation of certain inorganic materials under controlled conditions of temperature and incubation period which was done for five days incubated at 27°C in BOD_5 incubator (APAO, 1995).

$$BOD5 = (DO - D5)/P$$

Where, Do is the dissolved oxygen (DO) of the diluted solution after preparation (mg/l). D5 is the DO of the diluted solution after 5 day incubation (mg/l); P is the decimal dilution factor.

Chemical oxygen demand (COD)

Chemical oxygen demand test is useful in studying performance evaluation of river water treatment plants and monitoring relatively.

2.3 Determination of heavy metals by ICP-OES AND AAS

Inductively coupled plasma-optical emission spectrometry (ICP-OES) is an attractive technique that has led many analysts to ask whether it is wiser to buy an ICP-OES or to stay with their trusted atomic absorption technique (AAS) (1). More recently, a new and more expensive technique, inductively coupled plasma-mass spectrometry (ICP-MS), has been introduced as a routine tool (2). ICP-MS offers initially, albeit at higher cost, the advantages of ICP-OES and the detection limit advantages of graphite furnace-atomic absorption spectrometry (GF-AAS). Unlike the famous prediction by Fassel, " that AAS would be dead by year 2000.", low cost flame AAS will always have a future for the small lab with simple needs. More recently several ICP-OES spectrometers are able to reach to 120 nm (3), thus enabling the determination of Cl at the primary wavelength of 134.664 nm with sub-ppm detection limits. The simultaneous ICP-OES can be faster for a large numbers of elements, but more expensive, than sequential ICP-OES. This greatly depends on the number of elements, and the concentrations required. Heavy metals are important for all living organisms in varying amounts, such as iron, copper, zinc and cobalt, for proper growth. However, the excessive amount of these heavy metals can also produce toxic effects. Thus, the determination of the amounts of heavy metals is especially important where there is a risk of having anthropogenic influence on aquatic environment. Before analysis for heavy metals, the effluent and water samples were filtered through Whatman no. 541 filter paper Whatman, Germany) into 100 ml of prewashed plastic bottles and the analytical grade HCl was used to adjust water pH to 3.5. After that the samples were kept in a room temperature until analysis. Cadmium (wavelength 228.8 nm), Chromium (wavelength 357.9 nm), Copper (wavelength 324.8 nm), Manganese (wavelength 279.5 nm) and Lead (wavelength 283.3 nm) specific hollow cathode lamps were used to analyze the samples. The instrument has a minimum detection limit of 0.01 mg/l for Cd, 0.10 mg/l for Cr, 0.03 mg/l Cu, polluted water bodies. It is used as a measure of oxygen requirement of a sample that is susceptible to oxidation by a strong chemical oxidant. Chemical oxygen demand was done with the closed reflux method in which results were obtained in 3-4 hour. The test is useful in studying performance evaluation of wastewater treatment plants and monitoring relatively polluted water bodies. We took 15 ml COD digestion tubes (pre-washed with dilute H_2SO_4) and added the following in sequence as transferred 0.50 ml wastewater sample (Inlet) or 1.00 ml treated sample. Then 2.5 ml standard potassium dichromate digestion reagent was added slowly and mixed. Further, 3.5 ml sulfuric acid reagent was added through the side of the tubes and allowed to settle at the bottom. The contents was capped and mixed (wear gloves as the contents are very hot) and cooled. Again, transfer tubes in the pre-heated COD digested at 150°C in 2 h. 3 blanks was applied by substituting DW for sample and the process continued exactly as the sample. In a titration, the contents of the COD digestion tube in 100 ml beaker were transferred. Thereafter, distilled water was added to make the volume to 50 ml. Finally, 1-2 drops of Ferroin indicator was added and titrated against 0.05 M ferrous ammonium sulfate (FAS) solution (Rodríguez-Abalde et al., 2012).

COD as mg O_2/L= (A-B) × M × 8000/sample in ml

Where,

A = ml FAS used for blank;

B= ml FAS used for sample

M= morality of FAS.

level was 2.9×10-3 ohm-1cm-1. Finally, the TDS of the wastewater samples contained 567 to 956 ppm.

0.02 mg/l for Mn and 0.2 mg/l for Pb in the flame method. Samples were aspirated through nebulizer and the absorbance was measured with a blank as a reference. Calibration curve was obtained using standard samples (containing 0.5, 1.0, 1.5 and 2 mg/l for Cd, 0.5, 1.0, 2.0, and 3.0 mg/l for Cr, 0.2, 0.4, 0.8,1.0 and 2.0 mg/l for Cu, 0.1, 0.2, 0.4, 0.8 and 1.0 mg/l for Mn, 1.0, 2.0, 4.0, 8.0 and 10.0 mg/l for Pb). The correlation coefficient was found for Cd 0.998, for Cr 0.999, for Cu 0.999, for Mn 0.999 and for Pb 0.999. The sample had to be diluted many folds to keep the results in the analytical range. The heavy metals (Pb, Cd, Cr, Cu and Mn) concentrations in all samples were determined by atomic absorption spectrophotometer (AAS) (Model AA-6800, Shimadzu Corporation, Japan) using an air-acetylene flame with digital read-out system (Kenawy et al., 2000; Loska and Wiechuła, 2003; Tapia et al., 2012).

2.4 ICP-OES interferences

Spectral

ICP-OES spectral interferences are more numerous and are more difficult to eliminate. There are more than 50,000 ICP-OES spectral lines documented, and the matrix can cause considerable problems which make a high resolution spectrometer mandatory for the analysis of samples such as steels, chemicals, and rocks. Inter element correction and spectral stripping used extensively in simultaneous ICP-OES can have only limited success due to the increase of uncertainty.

Matrix effects

Like ICP-MS, ICP-OES can use internal standards to overcome matrix effects such as spray chamber "adaptation" effects and viscosity differences between samples and calibration standards.

Ionization

Interference from easily ionizable elements can be minimized by careful choice of individual element conditions or by adding an ionization buffer, i.e. by adding an excess of aGroupIelement.

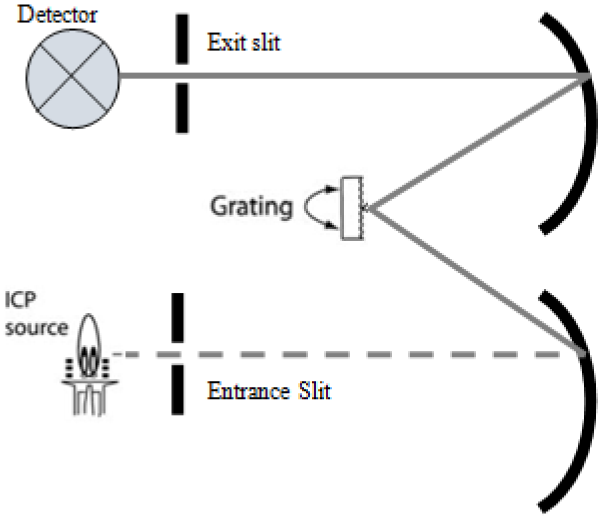

Figure 2: Typical sequential (monochromator) ICP-OES

2.5 GF-AAS interferences

Spectral

There are only a few spectral interferences in GFAAS when deuterium background correction is used, e.g. effect of Fe on Se, at 196.0 nm but these rare interferences can be eliminated by the use of Zeeman GF-AAS.

Background

For many matrices careful programming of the ash stage is required to minimize the background signal during the atomization. The use of chemical modifiers can be helpful in increasing the allowable ash temperature. For example, a Ni chemical modifier for Se determinations allows ash temperatures of up to1000 ºC before Se loss. The use of Zeeman background correction can give an improvement in accuracy compared with D2 arc background correction in many GF-AAS applications.

Vapor phase interferences

These can be caused by the atomization of the analyte into a cooler gas environment. These interferences have been minimized in recent years by isothermal tube design, and use of platforms to delay the atomization of the analyte, whereby the sample is atomized into a hot inert gas environment.

Matrix effects

Matrix effects are exhibited by varying retention of the analyte on the graphite tube depending on the sample type. The dry and ash stages can have a dramatic effect on the shape of the transient peak. The use of matrix modifiers (e.g. PdCl2) and hot injection can be quite effective in minimizing these effects and the use of peak area measurement can be advantageous in some cases.

2.6 Flame AAS interferences

Chemical

Due to the low temperature of the air/acetylene flame (2,200 ºC), there are many chemical interferences examples are PO4 on Ca and the effects of precious metals on other precious metals. The use of "releasing agents" can overcome these interferences, e.g. Lanthanum Chloride for the Ca in phosphate solutions and Uranium Oxide or Lanthanum Oxide for precious metals.

Matrix effects

Flame AAS, like ICP-MS and ICP-OES, uses a nebulizer and spray, so it has similar interferences such as viscosity differences between samples and calibration standards. Matrix matching is often mandatory (due to direct aspiration of the sample) and the method of standard additions is often used, especially because an internal standard is not possible on modern AA spectrophotometers. Spray chamber "adaptation" effects are less in Flame AAS probably due to the large droplet size and volume of aerosol in the spray chamber.

Back ground effects

For most applications the flame creates a different spectral background for different samples when compared with blank and standards. It is for this reason most elements are determined with the use of background correction, this involves the use of a D2 continuum source.

Total dissolved solids (TDS)

Recent ICP-OES spectrometers have been able to analyze routinely up to 10% TDS and even up to 30% for simple salt solutions. Although the analysis of 0.5% TDS for ICP-MS may be possible for a limited time-scale, most chemists are happier with 0.2% maximum TDS. This should be borne in mind when the original sample is a solid. The ultimate detection limit for some elements in ICP-MS may not be so impressive when expressed in the solid, compared with ICP-OES. Flame AAS can usually cope with up to 5% TDS although this figure is reduced to about 1% for N_2O/C_2H_2 flame work. GFAAS can cope with extremely high levels of dissolved solids.

Precision

ICP-OES has generally in-run precision of 0.3-2% RSD and again less than 3% RSD over several hours (for some spectrometers <1% for 4 hours). GFAAS, however, will generally have short-term precision of 0.5-5% RSD. Long-term precision is a function of the number of graphite tube firings, rather than time. In-run precision of flame AAS is excellent 0.1-1%, however, long term precision is poor especially if nitrous oxide/acetylene flame is used Constant manual "de-coking" of the burner may be required by the operator.

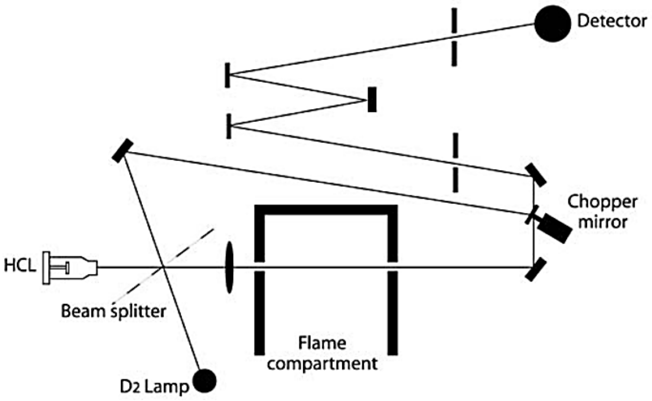

Figure 3: Typical Double Beam AAS

3. Result and Discussion

Table 1: Physical properties (color & odor) of various samples sites

	Site 1			Site 2			Site 3		
	Monsoon	Winter	summer	Monsoon	Winter	summer	Monsoon	Winter	summer
Color	Deep yellow	Deep yellow	Deep yellow	Ash color	Light ash	Light ash	Blackish	Light ash	Light ash
Odor	Pungent	Pungent	Pungent	No odor	No odor	No odor	No odor	No odor	No odor

Table 2: Chemical properties of monsoon, winter & summer season of samples at different sites

Sl. No	***Parameters***	***Site 1***			***Site 2***			***Site 3***		
		Monsoon	***winter***	***summer***	***Monsoon***	***winter***	***summer***	***Monsoon***	***winter***	***summer***
1	**DO**	5.4	6.8	4.8 mg/l	5.0	6.0	4.0 mg/l	5.2	6.2	4.2 mg/l
2	**BOD**	2.1	1.8 mg/l	1.6 mg/l	1.9	1.5 mg/l	1.4 mg/l	2.5	1.9 mg/l	1.5 mg/l
3	**COD**	3.5	3.1 mg/l	2.6 mg/l	3.0	3.0 mg/l	2.0 mg/l	3.4	3.3 mg/l	2.6 mg/l
4	**TDS**	598 mg/l	625 mg/l	789 mg/l	574 mg/l	602 mg/l	785 mg/l	565 mg/l	598 mg/l	784 mg/l
5	**TS**	-	-	-	-	-	-	-	-	-
6	**pH**	7.8	7.3	7.7	7.5	7.3	7.5	7.6	7.5	7.2
7	**Turbidity**	5.9 NTU	6.1 NTU	7.0 NTU	5.3 NTU	5.5 NTU	7.6 NTU	5.1 NTU	5.8 NTU	7.4 NTU
8	**Hardness**	168 mg/l	140 mg/l	188 mg/l	161 mg/l	158 mg/l	178 mg/l	169 mg/l	139 mg/l	186 mg/l
9	**Alkalinity**	210 mg/l	180 mg/l	225 mg/l	198 mg/l	155 mg/l	230 mg/l	208 mg/l	170 mg/l	228 mg/l
10	**Acidity**	-	-	-	-	-	-	-	-	-
11	**Conductivity**	810 µs/cm	800 µs/cm	990 µs/cm	800 µs/cm	900 µs/cm	900 µs/cm	811 µs/cm	800 µs/cm	980 µs/cm
12	**Nitrate**	2.1 mg/l	2.0 mg/l	3.1 mg/l	2.0 mg/l	2.1 mg/l	3.5 mg/l	2.1 mg/l	2.0 mg/l	3.3 mg/l
13	**Sulphate**	90 mg/l	82 mg/l	88 mg/l	88 mg/l	72 mg/l	76 mg/l	85 mg/l	80 mg/l	85 mg/l

Table 3: Heavy Metal Concentration of monsoon, winter &summer season in water samples at different sites (in ppm)

Sl. No	***Heavy Metals***	***Site 1***			***Site 2***			***Site 3***		
		Monsoon	***winter***	***summer***	***Monsoon***	***winter***	***summer***	***Monsoon***	***winter***	***summer***
1	**Zn**	0.015	0.011	0.012	0.017	0.014	0.012	0.015	0.011	0.011
2	**Cu**	0.046	0.047	0.05	0.048	0.045	0.06	0.045	0.046	0.05
3	**Pb**	0.06	0.02	0.02	0.09	0.02	0.02	0.07	0.02	0.03
4	**Mn**	0.055	0.041	0.045	0.056	0.040	0.046	0.054	0.041	0.044
5	**Fe**	0.185	0.21	0.29	0.189	0.19	0.30	0.184	0.20	0.28
6	**Al**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
7	**Hg**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
8	**Ni**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
9	**As**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
10	**Cd**	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Table 4: Heavy metal reported methodology and there wavelength (in nm)

S.no.	*Heavy metal*	*Reported method*	*Wavelength (in nm)*
1	Cd	Dithizone method, polarographic method, AAs	228.8
2	Cr	As Ag Pd chromate method, diphenylcarbazide method, AAs method	357.9
3	Cu	Spectrophotometric method, neocuproine method, by salicylaldoxime, AAs	324.8
4	Mn	Persulphate method, AAs	279.5
5	Pb	Polarographic method, spectrophotometric method, AAs method	283.3
6	Ni	AAs method	232.0
7	Tl	AAs method	276.8
8	Fe	Spectrophotiometric method, AAs	248.3
9	Zn	AAs method	213.9
10	Ca	AAs method	422.7
11	Mg	AAs method	285.2
12	K	AAs method	766.5
13	Na	AAs method	589.0
14	Ba	AAs method	554.0
15	Co	AAs method	240.7
16	As	Gutzeit method, AAs	193.7
17	Sn	AAs method	283.9
18	Pt	AAs method	214.4
19	Ru	AAs method	349.8
20	Li	AAs method	670.0
21	Hg	Dithizone method, flameless AAs method	570.0
22	Al	AAs	300.0
23	Se	Diaminobenzidine method, spectrophotometric method, AAs	
24	Be	Aluminon method, AAS	

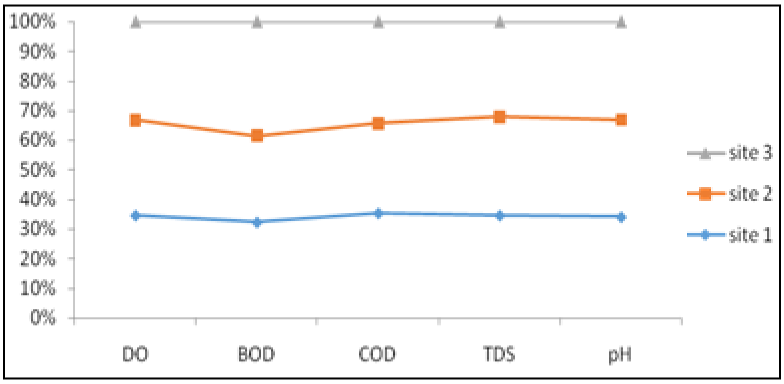

Figure 4: Graphical representation DO, BOD, COD, TDS, pH

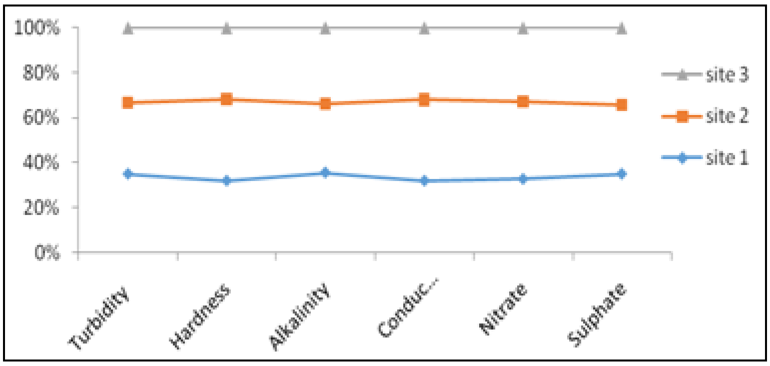

Figure 5: Graphical representation turbidity, hardness, alkalinity, conductive, nitrate and sulphate for deferent sites

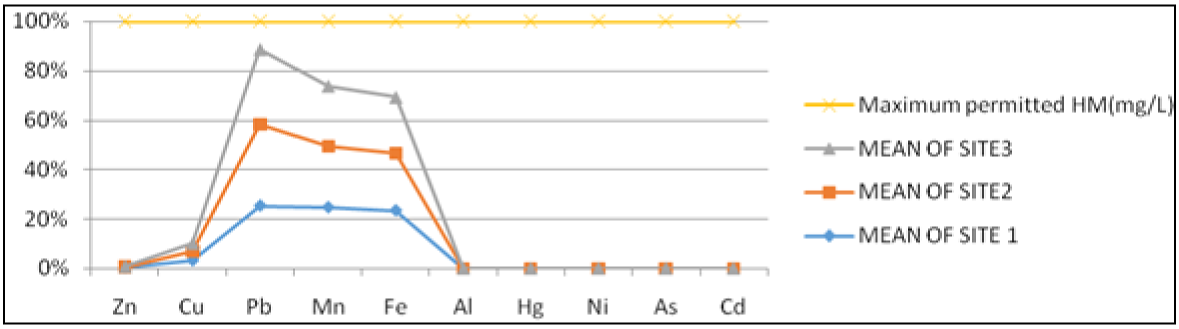

Figure 6: Graphical representation of heavy metals of different sites (mean of monsoon, winter & summer of each site and maximum permitted heavy metal concentration (mg/L) for drinking water quality and protection of fresh water aquatic life)

4. Conclusion & Future Works

As a lower dense and growing area, Kasdol is becoming polluted as the effluents are descending their way to the River and canals. The pH value showed that the effluents disposed are of great corrosion characteristics. The hardness of river water samples in this area was quite high. The BOD, COD values indicate that the levels of contamination are increasing; although. If proper steps cannot be taken, then contamination in aquatic system will be increased day by day. That is why; it is high time to take proper precautions and strong monitoring so that the environment can be sustained in its original state.

In our research we just taken total 3 area samples of different seasons and using AAS method we found that the water is almost usable for drinking and agriculture purpose, and mean value of all the season shows that the contamination of various metals is below the standard level till now. We proposed to take sample of at least 15 areas and about samples of each 2 months in a year, and using clustering analysis method and typical AAs method compare the standard of the water so that we can able to find the actual contamination of heavy metal in the surface water of Jonk river and increasing contamination of heavy metals of the river.

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