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Assessment of Physico-Chemical Properties and Toxic Heavy Metals in Water from Kali River, Meerut Region, India

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Abstract— *The present study is to deal with the assessment of physico-chemical and concentration of the heavy metals- Hg, Cr, Fe, Mn, Co, Cu, Ni, Zn, Pb, Cd in water samples collected from Kali River at 3 different sites in Meerut region, namely Saini Village, Begum Pul and Kankarkhera during pre-monsoon, monsoon and post-monsoon for one year June 2015-July 2016. The Results showed that pH ranged from 7.1 to 8.3, Range of Total Dissolved Solids (TDS) were 1643 mg/L to 3145 mg/L, the values obtained were significantly higher than limit as per IS and TSS ranged from 164 to 284 mg/L. Conductivity was found between* 769 to 1365 µs/cm. *BOD and COD values of all sites were found very high. All samples showed very insignificant amount of DO whereas desirable DO levels is more than 4 mg/L. Sulphate and Nitrate were found in range from 50 to 150 mg/L and 19 to 41 mg/L respectively and within the prescribed limit by IS. Heavy metal analysis showed that Pb (0.046-0.231 mg/L), Cr (0.013-0.053 mg/L), Cd (0.001-0.019 mg/L), Hg (0.001-0.018 mg/L), Cu (0.033-2.167 mg/L), Mn (0.187 – 0.484 mg/l), Ni (0.019-0.091 mg/L), Zn (0.137-5.641 mg/L), Fe (3.374-6.846 mg/L), Se (ND- 0.012 mg/L) and As (ND-0.018 mg/L). The study has indicated that almost all the parameters are at the higher levels than the prescribed limit not only for drinking water as given by IS & WHO, but also for irrigation purpose as recommended by FAO and therefore proper treatment are required. Generally large scale industries have effluent treatment plants, but at other end small scale industries are not following the guidelines set for the industrial effluents.*

Keywords— Physico-chemical, Heavy Metal, waste water, Industrial Area and ICP-MS, ND=Not Detected, FAO, IS

1. Introduction

Human health and environmental quality are undergoing degradation by the increasing amount of wastes being produced. Wastes are complex in nature depending on the sources of generation and its environmental fate once generated. Of all the classification of wastes available, industrial wastes is the most occurring source of water pollution (Oyediran et al, 1997). Although the fresh water in nature is very little; approximately 1% but due to over industrialization this fresh water recourses gradually decline. In the developed world, domestic sewage, industrial and agricultural wastes are treated at sewage central works to reduce its toxicity and discharged into rivers and stream, but in developing countries, it lacks. Most of the rivers following the residential area are final discharge point for effluent from industrial area and municipal waste (Moscow et al., 2011). Studies of water quality in various effluents revealed that man-made activities have an important negative impact on water quality in the downstream sections of the major rivers. This is a result of cumulative effects from upstream development but also from inadequate wastewater treatment facilities (Chang et al, 2008). In most developed and developing countries, rapid industrialization and man's constant quest for comfort as well as change in taste and fashion have resulted to various forms of advancement in science and technology (Tuner et al, 1990). The trend of urbanization in India is exerting stress on civic authorities to provide basic requirement such as safe drinking water, sanitation and infrastructure. Prior to population explosion, agricultural and industrial activities have been practiced on a very small scale (Akinbile, 2006), The rapid growth of population has exerted the portable water demand, which requires exploration of raw water sources, developing treatment and distribution systems (Choksi et al, 2015). Heavy metals occur as natural constituents of the earth crust, and are persistent environmental contaminants since they cannot be degraded or destroyed. To a small extent, they enter the body system through food, air, and water and bio-accumulate over a period of time. (Duruibe et al, 2007). Heavy metal is present in diminutive quantities in the water. However, in the recent past, freshwater pollution due to heavy metals has become a hazard due to discharge of industrial effluents and Municipal waste. Heavy metals like Mn, Fe, Ni, Cu, Zn and Cr are essential for the growth of organisms, while Pb, Cd, Hg and Ag are not biologically essential, but definitely toxic. Even the essential heavy metals may be beyond optimum threshold levels, hazardous and toxic (Hariprasad N. V. et al, 2013). Effluent discharge into the environment with enhanced concentration of nutrient, sediment and toxic substances may have a serious negative impact on the quality and life forms of the receiving water body when discharge untreated or partially treated (Forenshell, 2001; Schulz and Howe, 2003, Ewere, 2014). In addition, waste water is available source of micronutrient (e.g. N, P, and K etc.), inorganic matter and organic matter, which are needed for maintaining for fertility of soil (Hait, 2014), but in excess concentration these could be toxic and deleterious.

2. Method & Materials

2.1 Sample collection

In this current study, Sampling was done during pre-monsoon, monsoon and post-monsoon for one year from June 2015 to July 2016 from 3 different sites of Kali River in Meerut Region as described in Table 1. The procedures used for the sampling, storge and analysis of the samples were as per guideline given by APHA, 92012) and CPCB. Samples were collected in highly pure and clean glass bottles of 5 litres capacity rinsed with hexane, tightly capped, labeled properly and brought back to the laboratory for testing.

TABLE.1: Table showing the station code and description of the water sampling stations of the study area

S. No.	Source of Pollution	Sampling Site	Code of sampling sites
1.	*Industrial Area*	Saini Village	K1
2.	*Industrial Area and Municipal Waste*	Begum Pul	K2
3.	*Industrial Area and Municipal Waste*	Kankerkhera	K3

2.2 Analysis of Physico-chemical Characteristic and Heavy Metal

The methods for all parameters were followed as per APHA, (2012). The parameters pH was analysed on site, while other parameters i.e. Electric conductivity, DO, COD, BOD, TDS, TSS, Nitrate, Sulphate & Potassium were analysed in laboratory as per APHA, (2012) and Heavy metals were analysed by using ICP-MS (Inductively coupled plasma mass spectrometer).

TABLE.2: Detail of Specification for drinking water as per IS

S. No.	Parameters	Unit	IS (for drinking water)
1	pH	_	6.5-8.5
2	EC	µs/cm	-
3	TDS	mg/l	2000
4	TSS	mg/l	-
5	BOD	mg/l	-
6	COD	mg/l	-
7	DO	mg/l	-
8	Sulphate	mg/l	200

TABLE.3: Table showing Specification for drinking water & irrigation water as per IS & FAO

S. No.	Parameters	Unit	IS (for drinking water)	FAO (for irrigation water)
1	Pb	mg/l	0.01	5
2	Cd	mg/l	0.003	0.01
3	Cr	mg/l	0.05	0.01
4	Ni	mg/l	0.02	0.2
5	Cu	mg/l	0.05	0.2
6	Fe	mg/l	0.3	5
7	Zn	mg/l	5	2
8	Se	mg/l	0.01	0.02
9	As	mg/l	0.01	0.1
10	Hg	mg/l	0.001	-
11	Mn	mg/l	0.1	0.2

3. Results & Discussions

3.1 Physico-chemical characteristic in samples

PH

pH is the hydrogen ion concentration which measures acidity and alkalinity of aqueous solution. Waste water discharge from Industries and municipal waste has both acidic and alkaline content. pH values ranged from 7.1 to 8.3 as depicted in fig 1. However, when pH value of three seasons are considered, it was found to be slightly alkaline .The lowest pH value was 7.1 at K1 site and highest pH value was 8.3 at K3 site. pH is one of the important biotic factors as index for pollution. Obtained values were exceeding the limits set by Indian standard (IS) for drinking water.

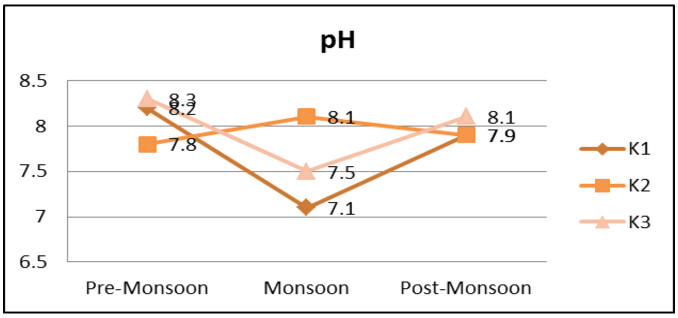


Fig.1. Variation in pH of water samples at different sites for the different seasons.

Electrical Conductivity

Conductivity is a measure of the ability of aqueous solution to conduct an electric current and this depends upon the presence of ions, their concentration, mobility and temperature of water. It is constructive indicator for measuring salinity or total salt content of waste water (Sudaram et al 2014). In investigation, conductivity of all samples from all sites was found higher and ranged from 769 to 1365 µs/cm. Season wise, conductivity was found higher in post-monsoon as depicted in fig 2.

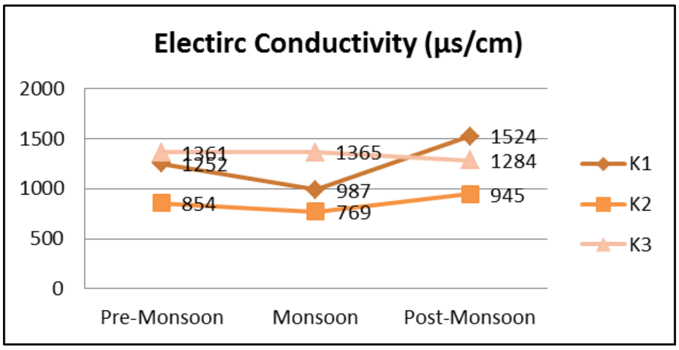


Fig.2. Variation in EC of water samples at different sites for the different seasons.

Total Dissolved Solids

TDS was noted in range from 1643 mg/L to 3145 mg/L. TDS is only measure of filtrate water sample. TDS causes gastro-intestinal problems and reduces the moistness in human beings (WHO, 1997). Seasonally, TDS was found higher in pre-monsoon. The Discharge of water with a high TDS level would have adverse effect on aquatic life and consumption of water with high TDS has much adverse effect on health and has been reported to cause, respiratory system, nervous system, disorders of alimentary canal, miscarriage and cancer (Reddy, 2001)

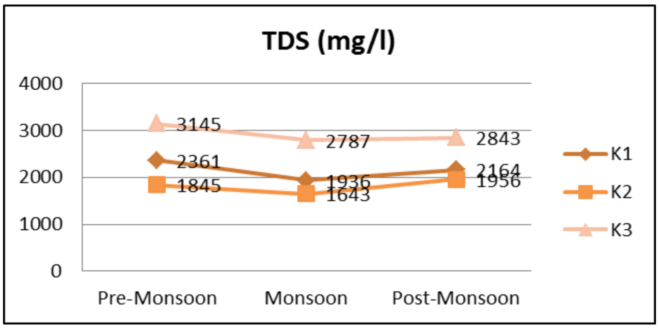


Fig.3. Variation in TDS of water samples at different sites for the different seasons.

Total Suspended Solids

The total suspended solids affect clarity of water and are the cause of suspended particle inside the water body of consumer and water gets and hold more heat which has adverse effect on aquatic life. In this investigation, it shows high TSS values effluent of all three site (K1, K2 & K3) were higher and ranged from 164 to 284 mg/L as depicted in fig 4.

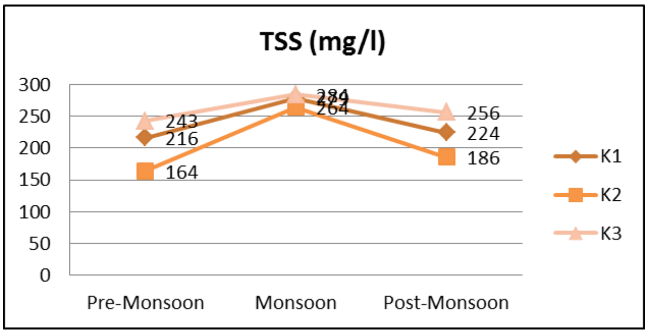


Fig.4. Variation in TSS of water samples at different sites for the different seasons.

Biological Oxygen Demand

Biological Oxygen Demand is the measure of the oxygen required by microorganisms while breaking down organic matter. In this investigation, it ranged from 321 to 374 mg/L, 376 to 437 mg/ L and 563 to 640 mg/L at K1, K2 and K3 site respectively. It showed that BOD value of all samples from all sites were higher. Seasonally, it was higher during pre-monsoon and site wise, at K3 sites. As low BOD content is an indicator of good quality water, while a high BOD indicates polluted water. BOD directly affects the amount of dissolved oxygen (DO) in rivers and streams. The greater the BOD, the more rapidly oxygen is depleted in the water.

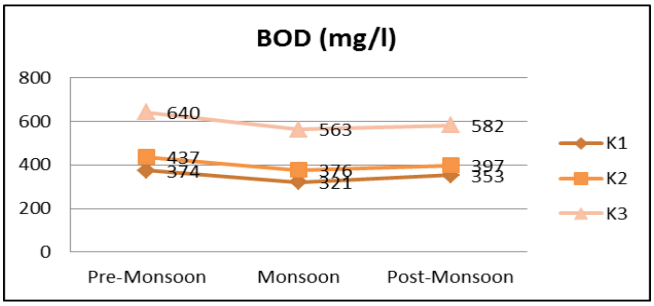


Fig.5. Variation in BOD of water samples at different sites for the different seasons.

Chemical Oxygen Demand

The chemical oxygen demand (COD) is measure of the oxygen equivalent of the organic matter content of the sample. The COD values ranged from 832 to 954 mg/L at K1 site, 943 to 1073 mg/L at K2 site and 856 to 974 mg/L at K2 site. In this investigation, COD values of all sites were higher as depicted in fig 6. High COD value indicates the toxic state of the waste water along with the presence of biologically resistant organic substances (Dutta, 1999).

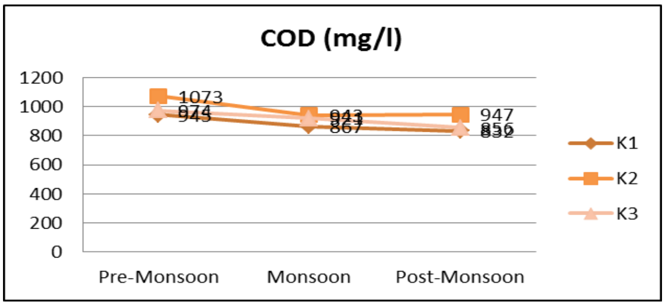


Fig.6. Variation in COD of water samples at different sites for the different seasons.

Dissolved Oxygen

Dissolved oxygen is important water quality parameter which determines organic pollution of water (Orebiyi E.O et al., 2010) and DO was found between 1.9 and 3 mg/L at K1 site, 2.7 and 4.3 mg/L at K2 site and 1.3 and 1.7 mg/L at K3 site. Dissolved oxygen levels were found to be very low and indicated the increased concentration of organic matter. The presence of free oxygen in water is a signal of the ability of that water to support biological life.

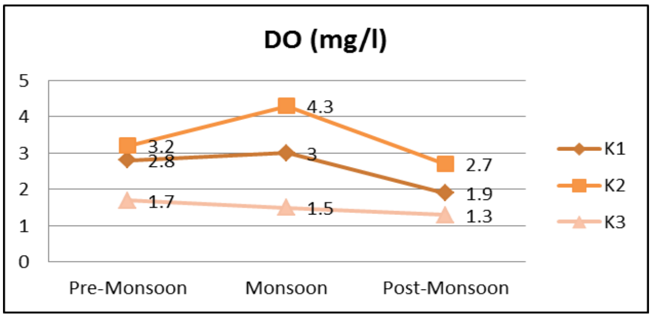


Fig.7. Variation in DO of water samples at different sites for the different seasons.

Sulphate

Sulphate values for all sites were found in range within the prescribed limit by IS and raged 50 to 150 mg/L.

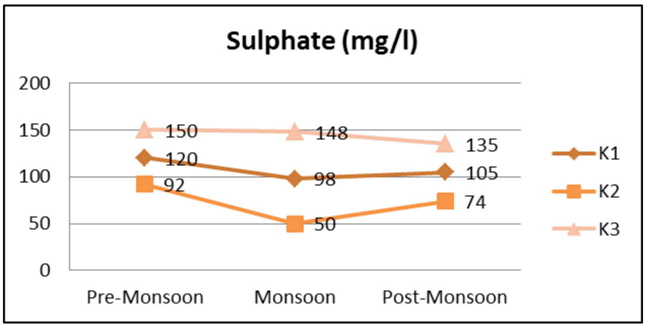


Fig.8. Variation in Sulphate of water samples at different sites for the different seasons.

Nitrate

In this study, Nitrate values for all sites were found within the limit prescribed by Indian Standard and ranged from 19 to 41 mg/L.

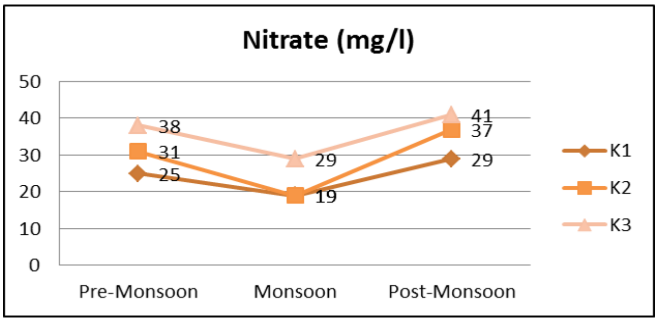
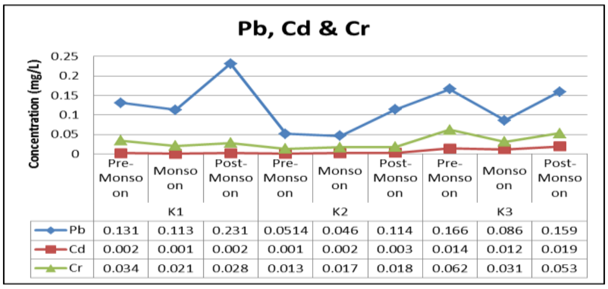


Fig.9. Variation in Nitrate of water samples at different sites for the different seasons.

3.2 Heavy metals presence in samples

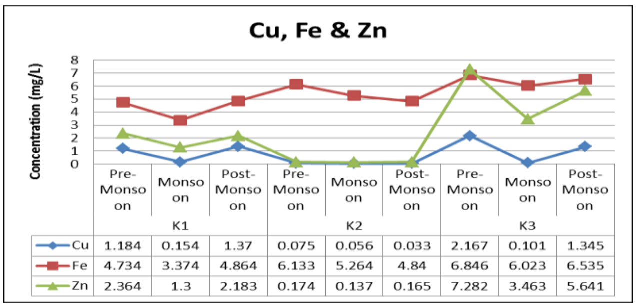
The analytical concentrations of the heavy metals in the effluents and water samples are listed on Tables 2. The results from heavy metal analysis showed that Pb (0.046-0.231 mg/L), Cr (0.013-0.053 mg/L), Cd (0.001-0.019 mg/L), Hg (0.001-0.018 mg/L), Cu (0.033-2.167 mg/L), Mn (0.187 – 0.484 mg/l), Ni (0.019-0.091 mg/L), Zn (0.137-5.641 mg/L), Fe (3.374-6.846 mg/L), Se (ND- 0.012 mg/L) and As (ND-

0.018 mg/L). The heavy metals and trace elements i.e. Pb, Cr, Cd, Hg, Cu, Ni, Mn, Fe and Zn were found above limit prescribed by FAO for irrigation water and IS for drinking water. It shows that this effluent cannot be used even for irrigation purpose. This was also due to the nature of raw materials used in the industry and municipal wastes. Similar study was reported by P. Ramesh, 2016.



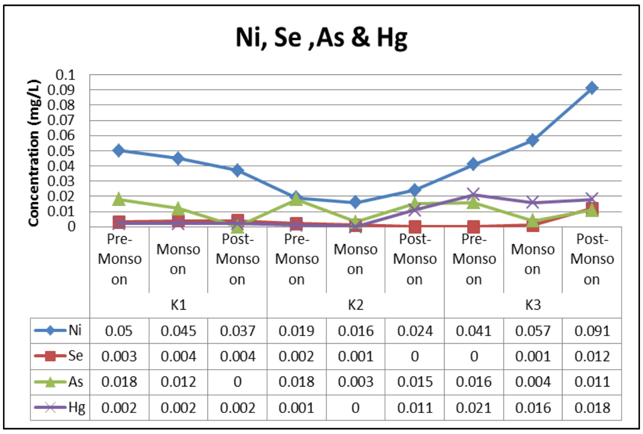
	K1 Pre-Monsoon	K1 Monsoon	K1 Post-Monsoon	K2 Pre-Monsoon	K2 Monsoon	K2 Post-Monsoon	K3 Pre-Monsoon	K3 Monsoon	K3 Post-Monsoon
Pb	0.131	0.113	0.231	0.0514	0.046	0.114	0.166	0.086	0.159
Cd	0.002	0.001	0.002	0.001	0.002	0.003	0.014	0.012	0.019
Cr	0.034	0.021	0.028	0.013	0.017	0.018	0.062	0.031	0.053

Fig.10. Variation in Pb, Cd & Cr concentration in water samples at different sites for the different seasons.



	K1 Pre-Monsoon	K1 Monsoon	K1 Post-Monsoon	K2 Pre-Monsoon	K2 Monsoon	K2 Post-Monsoon	K3 Pre-Monsoon	K3 Monsoon	K3 Post-Monsoon
Cu	1.184	0.154	1.37	0.075	0.056	0.033	2.167	0.101	1.345
Fe	4.734	3.374	4.864	6.133	5.264	4.84	6.846	6.023	6.535
Zn	2.364	1.3	2.183	0.174	0.137	0.165	7.282	3.463	5.641

Fig.11. Variation in Cu, Fe & Zn concentration in water samples at different sites for the different seasons.



	K1 Pre-Monsoon	K1 Monsoon	K1 Post-Monsoon	K2 Pre-Monsoon	K2 Monsoon	K2 Post-Monsoon	K3 Pre-Monsoon	K3 Monsoon	K3 Post-Monsoon
Ni	0.05	0.045	0.037	0.019	0.016	0.024	0.041	0.057	0.091
Se	0.003	0.004	0.004	0.002	0.001	0	0	0.001	0.012
As	0.018	0.012	0	0.018	0.003	0.015	0.016	0.004	0.011
Hg	0.002	0.002	0.002	0.001	0	0.011	0.021	0.016	0.018

Fig.12. Variation in Ni, Se, As & Hg concentration in water samples at different sites for the different seasons

4. Conclusion

In this study and from ongoing observation of Physico-chemical parameters and Heavy metals, it can be concluded that Kali River shows the characteristic of eutrophication. As most of the parameters were found high in concentration compared to the standards prescribed by IS and WHO for drinking water and FAO for irrigation purpose, So water from this water body can used neither for drinking nor irrigation purpose. The high level pollution from the industrial effluents & municipal waste which cause environmental problems, will affect plant, animal and human life directly and indirectly. Hence study reveals the need of proper effluent treatment before disposal of waste water.

5. Acknowledgment

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