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Study on yearly variation of physico-chemical parameters of Sone river water at Koilwar site in Bihar, India

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Abstract
Fresh water is necessary for healthy living. River water is used for various purposes such as drinking, bathing, irrigation etc. This natural resource is being polluted by indiscriminate disposal of sewage, industrial waste and human activities which affect quality of river water. Therefore, it is necessary for monitoring the water quality of river by analysis of various physicochemical parameters. The objective of study on the yearly variation and physico - chemical parameters of Sone river water at Koilwar site in Bihar, India. The variable data of samples are within prescribed limits as suggested by World Health Organisation and Indian Standard institute and BIS desirable limit for drinking, irrigation, bathing purpose. Yearly variation in physical and chemical parameters like pH, Electrical conductivity, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Coliform, Fecal Coliform in water were analyzed for a period of year 2001 to 2014. The analysis of the water quality parameters of the Sone river clearly indicated high pollution load on the river water. To maintain the sound environment and healthy ecosystem of the river and the surrounding areas, proper management and monitoring of water quality of the river is needed.

Keywords: Physico-chemical parameters, Biochemical oxygen demand (BOD), Chemical Oxygen Demand (COD), Sone river, Water quality

Introduction
Water is the principal need of life on earth, and is an essential component for all forms of lives, from micro-organism to man. The unplanned urbanization and industrialization (Singh *et al*., 2002) [8] has resulted in over use of environment (Petak, 1980) [9] in particular of water resource. A kind of crises situation has made getting clean water a serious problem. Natural water bodies like rivers are subjected to pollution comprising of organic and inorganic constituent. Fresh water is necessary for healthy living. River water is used for various purposes such as drinking, bathing, irrigation etc. This natural resource is being polluted by indiscriminate disposal of sewage, industrial waste and human activities which affect quality of river water. Therefore, it is necessary for monitoring the water quality of river by analysis of various physicochemical parameters. (Bhatnagar *et al*. 2012) [1] studied physico- chemical analysis of some water samples in Rewa city (M.P.), India. The overall result of study indicate that water quality at Rewa region is not good and major cause of pollution is population density and obviously discharge of domestic sewage, domestic effluents, agricultural runoff in the area. (Kanse *et al* 2005) [5] studied the physico- chemical characteristics of flowing water of major rivers in Pune city. The results they obtained in the investigations revealed that the discharge of untreated industrial effluent and sewage have contributed considerable pollution, hence the water of these rivers in unsafe for consumption or human use. (Joshi and Shrivastava, 2006) [6] studied drinking water quality in Tarai, region of Uttaranchal and found that iron and magnesium were slightly higher at few location as compared to the permissible standard and fecal contamination was also noticed in some of drinking water samples. (Vijayvergia, 2005) [4] showed that the Sukha Naka down section of the river Ahar, Udaipur is highly polluted. He got higher values of COD, total alkalinity and free carbon dioxide. (Govindaradjane, 2007) [5] studied arsenic concentration in ground water of Pondicherry region and observed that the concentration of arsenic is higher.(Sinha and Saxena, 2007) [6] showed that the drinking water at Hosanpur, J.P. Nagar India is found to be highly contaminated with reference to most of the physico- chemical parameters studied.

(Agarkar and Thombre 2006) [7] assessed drinking water quality in schools of village of Buldhana district and observed that, the water quality is unsatisfactory.

Apart from the considerations related to develop to the development of water resources there has been an increasing concern in all communities over the impact of water quality on public health and general environmental conditions. The largest area where environmental pollution appears is water resources. Water pollutions not only results in significant economic losses, but may also lead to life threatening levels depending on the type and intensity of pollutants. Consequently, the society itself stresses the need for a better understanding of how water quality characteristics evolve in space and time under natural and manmade conditions.

The objectives of the present work were to (1) To assess physico-chemical characteristics of water of Sone river at Koilwar site. (2) To establish the correlation between the parameters and the years.

Material and method

Study area

Sone river is a rainfed river and rises at an elevation of 600 m at Amarkantak in Madhya Pradesh state of central India. The river drains 71,259 km^2 area (Rao 1995) [10] and joins the Ganga about 30 km upstream city of Patna.

The river water was sampled at latitude 25°34′11″N and longitude 84˚47′52″E near a railroad bridge. The sampling site was approximately 16 km upstream confluence of the Ganga. River width at the sampling site varied from 150 to 600 m. The site was marked with intense riverbed sand mining besides bathing, defecation, cattle washing, fishing, etc.

Koilwar (also spelt Koelwar) is a notified area in Bhojpur (Arrah) district in Bihar, India. Koilwar is located at 25.58°N 84.80°E. It has an average elevation of 39 metres (128 ft). It is situated on the bank of Son River. Koilwar bridge is situated on the Sone river; its steel rail road bridge called as Abdul Bari bridge made before independence in 1900 by British rule. A two lane road (NH 30) runs just under the rail tracks. Sand mining near the pillars of this old bridge has created structural problems recently.

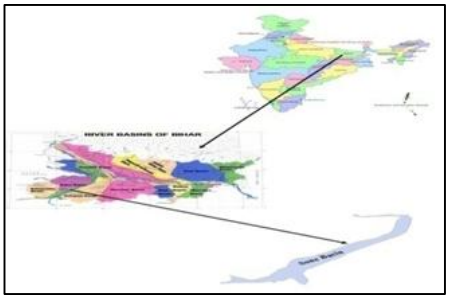

Fig 1: (a) Location of study area

Fig 1: (b) Location on Google earth map.

Data collection

Physical and chemical parameters like pH, Electrical conductivity, DO, BOD, COD, TC, FC in Sone river water at Koilwar site recorded data of 14 years (2001-2014) collected from regional office at Patna of Central Pollution Control Board, Ministry of Environment, Forest & Climate Change, (Govt. of India). Collection, preservation, and transportation of water samples to the laboratory were as per standard methods (APHA 1998) [22].

Material requirement for sampling and analysis of water of Itinerary for the trip, personnel and sample transport arrangement, area map, sampling site location map, Icebox, weighted bottle sampler, D.O. Sample, Rope, B.O.D. bottles, sample containers, special sample containers, bacteriological and special sample, heavy metals, D.O. fixing and traction chemical and glassware, thermometer, tissue papers, other field measurement are sample identification forms, labels for sampling containers, field note bottle, pen, pencil, markers, soap and towel, match box,
spirit lamp, torch etc.

Table 1: Primary Water Quality Criteria for Bathing Waters.

Criteria		Rationale
pH value	6.5-8.5	The range provides protection to the skin and delicate organs like eyes, ears etc. which are directly exposed during outdoor bathing
Electrical conductivity (rmhos/cm)	< 2250	Irrigation, industrial cooling, and controlled disposal.
Dissolved oxygen (mg/I)	5 or more	The maximum dissolved oxygen concentration of 5 mg/I ensures reasonable freedom from oxygen consuming organic pollution = immediately upstream which is necessary for preventing production of anaerobic gases (Obnoxious gases) from sediments.
Bio-Chemical oxygen demand 3 days, 27^{0}C	3 or less	The bio – chemical oxygen demand of 3 mg/I or less of the water ensure reasonable freedom from oxygen demanding pollutants and prevent production f obnoxious gases.
Chemical oxygen demand (COD) mg/I	< 10mg/I	COD often is used as a measurement of pollutants in natural water to ensure no contamination from industrial source after treatments. Such level of COD ensure no contamination from industrial source after treatment
Total coliform (MPN / 100ml)	50	May glacial fed and spring fed rivers at the upstream, are direct source of drinking water. Contribution of total coliform in such pristine water is mainly through soil origin and may not be harmful while bathing.
Fecal coliform (MPN/100ml)	<1.8	Fecal coliform is considered as they are indicators of the bacterial pathogenicity through human origin and their presence renders the river water to many water borne disease likeurinary tract infection, shigellosis, ear and eye infection, cholera, skin diseases and typhoid etc. thus, unsuitable for drinking purposes while bathing.

pH value: pH value in water is determined by pH meter.

Electrical conductivity (EC): The electric conductivity of water is a measure of the ability of a solution to conduct an electric current; this ability depends upon the presence of ions, their total concentration, mobility and temperature of water. The conductivity of the water is one of the important parameter used to determine the suitability of water for irrigation. It is useful indicator for salinity or total salt content of waste water (Sagar, T. 2012) [17].

Biochemical Oxygen Demand: B.O.D in water is determined by bottle incubation for 3-days at 27 ˚C method using BOD bottle 300 ML, narrow mouth flare clip with tapered and pointed ground glass stoppers, water bath thermostatically controlled at 27 ± 1 ˚C, plastic tube, screw – pin and 5-10L water container, phosphate buffer solution, magnesium sulphate solution, calcium chloride solution, ferric chloride solution, acid and alkali solution, glucose-glutamic acid solution, sample dilute water etc.

Chemical Oxygen Demand: C.O.D. in water is determined by open reflux method using reflux apparatus, volume flask with flat bottle and with ground glass neck, standard potassium dichromate solution, sulphuric acid reagent, ferroin indicator solution standard ferrous ammonium sulphate standard potassium dichromate, mercuric sulphate powder, potassium hydrogen phthalate etc. (James, W.1993) [13].

Total and fecal coliform counts were based on multiple tube fermentation technique (APHA 1998) [22].

The physical and chemical properties were evaluated using central tendency (mean) and dispersion (standard deviation). One way analysis of variance (ANOVA) was used to test the difference in means of more than two groups (Zar 1999) [14].

Result and discussion.

Present paper results pH, EC, DO, BOD, COD, TC, FC for Sone river water of 2001 to 2014 at Koilwar site, Bihar, India.

Hydrogen Ion Concentration (pH):

pH plays vital role to examine the water quality assessment as it has great influence on biological and chemical processes in the water body (Ahmed *et al*. 2011) [34]. In the study area the pH of water collected at Koilwar site of 14 years ranged from 7.14 to 8.95, The highest pH was found 8.95 in the year 2006 and the lowest pH was found in the year 2010 during the period 2001-2014. The pH values were within the permissible level set by CPCB i.e. 6.5 to 8.5, It's express the Sone river water pH was moral, pH = >7. But all these pH values at different times of year were within the permissible limit. There were not significance variations in pH values in this analysis. Reaction involving carbonate system control most of the natural water pH. pH change quickly due to loss or gain of dissolved gases such as CO_2 and O_2. pH measure of the alkanity or acidity of water sample(Afrin *et al*. 2011) [35]. So the study area water was weak alkaline. The pH is in alkaline ranged which can be due to presence of alkali metals. Alkalinity of water is a major of its capacity to neutralize acids (Deepshikha *et. al*., 2008) [12] and provides on index for the nature of salts present in the samples. Total alkalinity of water samples ranged from 32.9 to 59 mg/L, which was within the prescribed limit of 120 mg/L (WHO). The low value of alkalinity shows absence of weak and strong bases such as carbonate, bicarbonate and hydroxides. The extreme pH of wastewater are generally not acceptable, as lower pH cause problems to survival of aquatic life. It also interferes with the optimum operation of wastewater treatment facilities. Aquatic organisms are affected by pH because most of their metabolic activities are pH dependent. Optimal pH range for sustainable aquatic life is pH 6.5-8.2. pH of an aquatic system is an important indicator of the water quality and the extent pollution in the watershed areas (Kumar *et al*., 2011) [26]. Water with high or low pH is not suitable for irrigation. At low pH most of the metals become soluble in water and therefore could be hazardous in the environment. At high pH most of the metals become insoluble and accumulate in the sludge and sediments. The toxicity of heavy metals also gets enhanced at particular pH (Kavitha, R.K *et. al*. 2012) [16]. Correlation analysis revealed significant positive correlation with all physico-chemical parameters (Table 2). The pH of water affects the solubility of many toxic and nutritive chemicals; therefore, the availability of these substances to aquatic organisms is affected. As acidity increases, most metals become more water soluble and more toxic. Toxicity of cyanides and sulfides also increases with a decrease in pH (increase in acidity). Ammonia, however, becomes more toxic with only a slight increase in pH.

Electrical conductivity

Conductivity itself is not a human or aquatic health concern because it is easily measured, it can serve as an indicator of other water quality problems. If the conductivity of a stream suddenly increases, it indicates that there is a source of dissolved ions in the vicinity. Therefore, conductivity measurements can be used as a quick way to locate potential water quality problems. Higher the value of dissolved solids, greater the amount of ions in water (Bhatt *et al.*, 1999) [23]. Increasing levels of conductivity and cations are the products of decomposition and mineralization of organic materials (Abida, 2008) [21, 33]. In present study, minimum 119 µmhos/cm in 2002 and maximum 365 µmhos/cm in 2012, all data EC within limits prescribed by WHO (1400µS/cm), and hence they are fit for irrigation. Thus suitable treatments are required before they are released to the sewage. The total concentration of soluble salts in irrigation water can be expressed for the purpose of classification of irrigation water as low (EC $\leq$ 250 µS cm^{-1}), medium (250–750 µS cm^{-1}), high (750–2250 µS cm^{-1}) and very high (2250–5000 µS cm^{-1}) salinity zones (Wilcox 1955). Conductivity showed significant positive correlation with all the parameters (Table 2).

Dissolved Oxygen (DO)

Dissolved oxygen is one of the most important parameters in water quality assessment and reflects the physical and biological processes prevailing in the water (Trivedi and Goel, 1984) [29]. The value of dissolved Oxygen is remarkable in determining the water quality criteria of an aquatic system. In the system where the rates of respiration and organic decomposition are high, the DO values usually remain lower than those of the system, where the rate of photosynthesis is high (Mishra *et al*., 2009) [30]. When the water is polluted with large amount of organic matter, a lot of dissolved oxygen would be rapidly consumed in the biological aerobic decay which would affect the water quality; the decreased dissolved oxygen in water would affect the aquatic lives (Chhatwal, 2011) [31]. Any forms of life cannot sustain without oxygen. Natural stream purification processes require adequate oxygen levels in order to provide for aerobic life forms. The maximum value of DO was noted as 9.3 mg/L of Sone river water in 2006 sample at Koilwar site while the minimum value of 7 mg/L was recorded in Sone river water at same site in 2003. The values of DO contents of water samples were above the standard limit (5 mg/L) as per WHO (1984). The

variation of CO_2 value was due to its absorptions by plants in photosynthesis and activity of other living organisms. Dissolved Oxygen is a particularly useful parameter for water and is an excellent indicator of quality. Its presence in surface water plays a key role in the self-purification and maintenance of aquatic life. However, its presence in urban water is seen as troublesome due to the possibility of corrosion of metal distributors (MC Bride and Rutherford 1983) [19]. Dissolved Oxygen is one of the fundamental factors of life. It enters the composition of atmospheric air with 21%, and represents approximately 35% of the dissolved gas in water at normal pressure (Bremond and Perrodon 1979) [20]. The DO of the water showed positive correlation with all other related parameters. In addition to this life-sustaining aspect, oxygen is important because the end products of chemical and biochemical reactions in anaerobic systems often produce aesthetically displeasing colours, tastes and odours in water (Hach *et al*.,1997) [25].

Bio-chemical Oxygen Demand (BOD).

Biochemical Oxygen Demand is a measure of the oxygen in the water that is required by the aerobic organisms. The biodegradation of organic materials exerts oxygen tension in the water and increases the biochemical oxygen demand (Abida, 2008) [21, 33]. BOD tests measures only biodegradable fraction of the total potential DO consumption of a water sample. High BOD levels indicates decline in DO, because the oxygen that is available in the water is being consumed by the bacteria leading to the inability of fish and other aquatic organisms to survive in the river (Pathak and Limaye, 2011). The BOD value was in the range of 0.2 mg/L to 2.8 mg/L So, BOD values are within the permissible limit i.e. 6.0 mg/L as prescribed by WHO (1991).

Chemical Oxygen Demand (COD).

Chemical Oxygen Demand is a measure of the oxidation of reduced chemicals in water. It is commonly used to indirectly measure the amount of organic compounds in water (Kumar *et al*. 2011) [26]. The measure of COD determines the quantity of organic matter found in water. This makes COD useful as an indicator of organic pollution in surface water (Faith, 2006). COD pointing to a deterioration of the water quality caused by the discharge of industrial effluent (Mamais *et al*., 1993). It is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values. Chemical oxygen demand was found to be 8 mg/L to 30 mg/L in 2001. High COD and BOD value indicates organic pollution. In the present investigation chemical oxygen remained showed slightly higher than bio-chemical oxygen demand values at all the water sample throughout the period of investigation. Relatively maximum COD value may cause oxygen depletion on reason of decomposition by microbes to a level detrimental to aquatic life (Ravindra and Kaushik 2003). Therefore the water of the river wasn't relatively safe for using drinking and maintaining aquatic ecosystem during study session. Showed high COD of water due to massive municipal and attempt for industrial activities around the river.

Total Coliform (MPN/100ml)

Results of bacteriological parameter show that Sone river water has the highest amount of total coliform (28000 MPN/100mL) in year 2005 while lowest value of total coliform was observed in 2004 (300 MPN/100mL) at Koilwar site. The trained in the level of total coliform in the samples relatively correlates with the level of dissolved chloride in the sample.

Levels of DO and BOD were well within the permissible limit prescribed for bathing class of river water by federal agency of India (CPCB 2005). However, levels of TC and FC exceeded the prescribed limits.

Table 1: Correlation Matrix of physico-chemical parameters for yearly variation during 2001-14.

	pH value	Conductivity µmhos/cm	DO mg/L	BOD mg/L	COD mg/L	TC MPN/100mL	FC MPN/100mL
pH value	1.00000						
Conductivity µmhos/cm	0.81225	1.00000					
DO mg/L	0.90554	0.87383	1.00000				
BOD mg/L	0.33466	0.50782	0.44288	1.00000			
COD mg/L	0.63799	0.58805	0.73177	0.05670	1.00000		
TC MPN/100mL	0.45766	0.55590	0.57496	0.03987	0.44300	1.00000	
FC MPN/100mL	0.43179	0.45440	0.47686	0.03702	0.26718	0.92358	1.00000

Conclusion

Management of water body essentially requires an understanding of physico-chemical and biological conditions. The aquatic environment is an area controlled by the changes such as light, heat, humidity and contamination of various effluents in the water body. It can also be said the overall productivity of a river is directly regulated by physico-chemical parameters. From the above investigation, it may be concluded that the values of different physico-chemical parameters are in the range prescribed by BIS (2003). So, the water of Sone river water at Koilwar site can be conveniently used both for irrigation and fishing purpose as well.

Thus we can conclude that the Sone River gets seriously polluted due to discharge untreated sewage and industrial effluents and the residues of pesticides and insecticides used in the farms are washed in to it from the point and non-point sources. As these toxic substances do not degrade, they remain persistent in the environment, and also have the ability to bio accumulate in the food chain, which might pose potential hazards in long run. Although the toxicity of these elements have been discussed and could itself become a research topic. The present data indicated the potential of further water quality deterioration and pollution from nearby anthropogenic inputs. Therefore, any future pollution should be reduced and this, of course, should involve the authority to control the pollution sources that would aggravate the pollution levels of river water. Regular monitoring and strict law enforcement is needed to develop a strategy to manage the environmental hazards due to these elements and to improve environmental protection of this area. Our present data should serve as baseline for future reference.

From the result of physico-chemical analysis of Sone river water at Koilwar site, it has been concluded that pH, EC, DO, BOD, COD, TC and FC are very high in concentration compared to the standards prescribed by WHO. Few samples show negligible amount of DO. Such effluent should not be discharged in to the nearby water body or soil without treatment. They are unfit for irrigation. The high level pollution of the industrial effluents cause's environmental problems which will affect plant, animal and human life.

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