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Assessment of toxicity level in Bagad River and its impact on ground water bodies

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Abstract: To determine combined effect of physic-chemical factors on aquatic life various environmental factors on aquatic life of Bagad River, its water quality was assessed using Bioassay test as summary parameter along with few other supporting parameters. The river, a tributary of Ganga River, which mostly carries industrial effluents of Gajraula industrial area, was studied twice for assessment of toxic nature of its water at four locations representing 23 Kilometer long stretch. Ground water quality along the river banks was also studied at four sites. Bagad river water was found highly toxic in the studied stretch with fish mortality ranged from 40% to 100% within 96 h. Sever impact at one ground water source at the site where river receives industrial effluents was noticed with 40-100% fish mortality. The study reflects that Bagad River water in the studied stretch was not at all fit to sustain aquatic life and also affecting ground water body significantly. Thus there is an urgent need to control effectively the industrial effluent discharges in the river.

Keywords: Bagad River, Bioassay, Industrial effluents, Acute toxicity

Introduction: Industrialization plays significant role in the progress of the country but, it leads to negative impact also especially on water resources mainly due to improper implementation of environmentally sound practices. In case of lotic environment, Each and every activity that occurs in its catchment area is reflected in the quality of water that flows through it, because the results of all human activities and lifestyle ultimately end up in river, through runoff (Soko, 2014). Industrial areas that have different type of industries generate effluents with complex chemical composition. Organic, inorganic substances present in the wastewater have direct impact on the aquatic life and hence, have high ecological relevance. Such effluents, exert sever and prolonged impacts on receiving water body. This impact on water body with loss of aquatic life is increasing with increase in industrialization that currently underway (Adebayo *et al.*, 2010; Agrawal *et al.*, 2010). Thus, assessment of such impact along with its prediction to take preventive action in time is the need of hour. Fishes are very sensitive to the changes in their environment and can play a significant role in assessing potential risks associated with contamination in aquatic environment and no river should be considered in a satisfactory condition unless fishes thrive well in it. The toxicity of complex industrial effluent is generally evaluated using fishes as test organism. Fishes were reported to respond to mutagens at low concentrations of toxicants in a manner similar to higher vertebrates (Lakra and Nagpure, 2009; Pandey *et al.*, 2011a; Pandey *et al*,. 2011b). Recent studies have demonstrated that Zebrafish (*Brachydanio rerio*) sensitivity is excellent research models in monitoring environmental pollutants, especially with the application of transgenic technology (Hill *et al.*, 2005; Dai *et al.*, 2014).

Presently the impact on aquatic system is generally assessed through physico-chemical approach which is unable to provide information on the combined effects of the various abiotic factors on biotic community, which may be additive, antagonistic or synergistic (Connon *et al.*, 2012). Bioassay test is a summary parameter provides response of test organisms to all the chemicals present in wastewater or effluent in terms of acute fish mortality. Since effluent is generally a complex mixture of chemicals and is difficult to characterize completely, use of acute toxicity test to measure aggregate toxicity of chemicals in an effluent is widely used during last few decades. This approach is known as Whole Effluent Toxicity or WET test. In 1984, the United State Environmental Protection Agency (US-EPA) recommended the use of WET test as a complement to the chemical specific analysis for the assessment of effluent discharges and its compliance with permit limitation. In India also, to regulate the wastewater discharges, bioassay standards based on WET test, have been notified for discharge of environmental pollutant under Environment Protection Act, 1986. Considering the above facts and reports from Gajraula and other adjoining areas that Bagad River, tributary of river Ganga, is polluting ground water, a study was undertaken to assess the water quality of this River, through bioassay test, along with its impact of groundwater aquifers. During dry season, the major source of water in the river is the wastewater discharges from Gajraula industrial area which houses various types of industries like distillery, pharma, chemicals, fertilizer, pulp & paper, food, dairy, automobile components etc. Few wastewater drains from villages located on its banks at Gajraula D/s also join the river. After Malwali Dagrauli (U/s Babrala) there is almost no water in the river and it became dry except during rainy season. Farming using ground water is very common on the banks of this river at Gajraula. Thus there is a probability of entering toxicants from ground water which in turn contributed by Bagad River to food chain. The outcome of present study will provide supporting information in this regards.

Material and methods:

Study area and sampling:

About 23 Km long Bagad River stretch from U/s Delhi-Moradabad Highway crossing (after receiving industrial waste) to Karan Khal was selected for the study. The river locations (Fig. 1) are Gajraula (D/s of industrial drain), Tigri khadar about 5 Km. D/s of first location, further 8.5 Km. D/s at Bhema Tikari and about 9 Km further D/s at Karan Khal on Hasanpur-Anoopsahar road. The characteristics of ground water on river banks were also studied at four locations i.e. Jheel (U/s of Gajraula industrial area as reference location), Gajraula industrial area, Tigri Khadar and Karan Khal. The Ground water samples were drawn from the depth of around 20-25 meters and collected either from Tube wells or Hand pumps, located about 100-500 meters away from Bagad River.

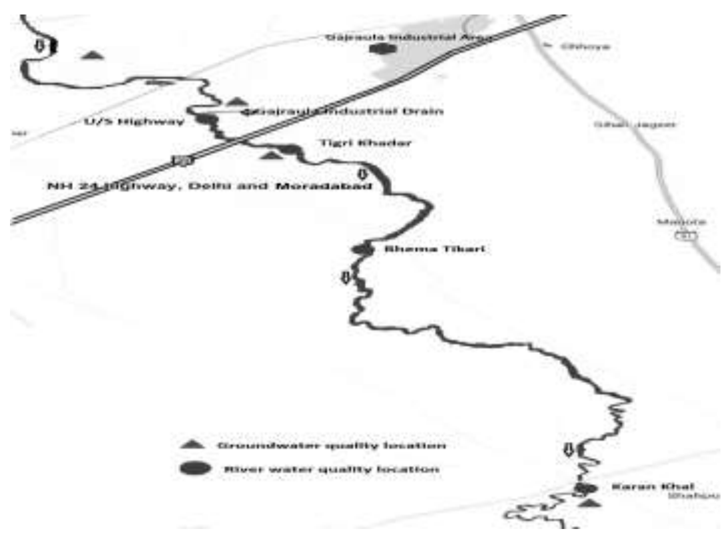

Fig. 1 Bagad River and ground water quality locations

The ground water was drawn by the studied tube well/ hand pumps from the depth of. The study was undertaken twice in November, 2015 and February, 2016 to cover the variations in water quality of Bagad River led

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by change in the effluent quality/quantity, if any, due to fluctuations in industrial activities.

During each round of sampling grab samples were collected from each location and preserved in ice. During sampling information were also collected from farmers/ villagers especially on the variations in the quality and quantity of river water and use of ground water at studied locations along with its impact.

Bioassay tests:

To evaluate toxicity level in the collected samples, bioassay tests were conducted by adopting test conditions as specified in the bioassay standard for discharge of environmental pollutants under E(P)A [Environment (Protection) Act], 1986. Accordingly, test conditions as depicted in Table 1, were followed as specified in Indian Standard Methods IS: 6582-1971 and IS: 6582 (Part 2), 2001 (revision of 1971 method). The collected samples from above mentioned locations were tested for Bioassay using Zebra fish (*Brachydanio rerio*), as test organism. Ten fishes were exposed in three liters of sample for 96 hours. The fishes were starved for 24 hours prior to their use in the test. Fish mortality along with time taken was recorded during the test and dead fishes were removed from the test containers. The DO, pH and temperature of test sample were measured on each day throughout the test.

Table- 1: Test conditions adopted for Bioassay test

Sl. No.	Type of conditions	Conditions
1	Test type	Static
2	Test vessel	5 liter glass beaker
3	Volume of test sample	3 liter/test
4	Water used for control/blank	Water used for storing the fish stock
5	Test organism	Zebra fish (*Brachydanio rerio*)
6	No. of test organisms exposed	10/test
7	Size and weight of test organisms	25-35 mm, 0.2 – 0.3 gm
8	Test temperature	24-26° C
9	Illuminative periods	14 hours
10	Aeration of test sample	If DO level falls below 4 mg/l
11	Test duration	96 hours

Physico-chemical analysis:

The collected samples were also analyzed for few physico-chemical parameters to get an idea about the presence of organic and inorganic materials in the collected samples. Dissolved Oxygen (DO) was measured in the field with the help of DO meter whereas, pH and conductivity was measured in laboratory using pH/Conductivity meter. Conductivity was measured only in the samples collected during second round of sampling. Observations regarding color and smell of the collected samples were also recorded in the field.

Results:

Bioassay test

Acute toxicity bioassays test observed in deferent treated groups at 96 hours of exposure of different location at Bagad River and ground water sources along its banks at different locations are summarized in Table 2, Fig. 2 and Fig. 3. First round of study reflects that the water of Bagad River was highly toxic and severity of this parameter was found reducing slightly and gradually at downstream locations on the basis of time interval for 100% mortality in zebrafish. This trend was not reflected in second round and toxicity level was also found low with 40% to 60% mortality of test organisms only which might be due to receipt of less toxic effluent and river water at various location represents different quality of effluent received over a period of time. Toxic level in the samples collected from the effluent carrying Gajraula drain was not found toxic during first round but found toxic with 40% mortality in second round.

Observations of drain were found not supporting the findings of river, the reason might be significant variation in the quality of drain water. Ground water samples from the bore wells on the bank of Bagad River at Gajraula only were found toxic with 40-100% mortality in Zebrafish. Different ground water sources (bore well) with different boring depth might led this variation in toxic level. 10% mortality in the ground water sample at Jheel might be attributed by some infection or injury caused to test organism during exposure as the source of ground water was same during both rounds of sampling and impact of any industrial effluent was not reported by villagers at this site during study. Further, this mortality is within the prescribed Bioassay standards for various industries and release of environmental pollutants.

Table-2: Level of fish mortality in Bagad River and ground water sources along its banks

Sl. No.	Location	November, 2015	February, 2016
River Bagad			
1	U/s Delhi-Moradabad highway crossing	100% mortality* (within 15 minutes)	40% mortality* (mortality start from day1)
2	Tigri khaddar	100% mortality* (within 4 hours)	60% mortality* (mortality start from day1)
3	Bhema Tikari	100% mortality* (within 4 hours)	40% mortality* (mortality start from day1)
4	Karan Khal	100% mortality* (within 6 hours)	60% mortality* (mortality start from 2^{nd} day)
Ground water sources			
1	Jheel (U/s of Gajraula industrial area)	0% mortality	10% mortality (mortality occur on day1)
2	Gajraula industrial area	100% mortality (within 24 hours)	40% mortality (mortality start from 2^{nd} day)
3	Tigri Khadar	0% mortality	0% mortality
4	Karan Khal	0% mortality	0% mortality

***Test conducted with controlled aeration**

Table 3: Physico-chemical characteristic of Bagad River and ground water sources
Unit:- DO: mg/l, Conductivity: µmhos/cm

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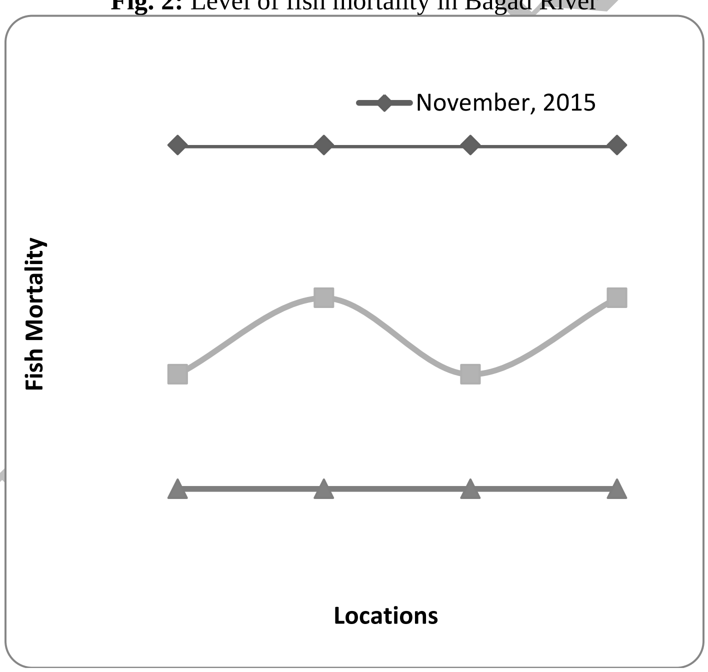
Sl. No.	Location	November, 2015 DO	November, 2015 pH	February, 2016 DO	February, 2016 pH	February, 2016 Conductivity	Physical Observations
River Bagad							
1	U/s Delhi-Moradabad highway crossing	0.2	8.1	0.6	7.4	11250	Blackish brown and highly turbid with pungent smell
2	Tigri khadar	1.6	8.3	0.9	7.7	11930	Blackish and highly turbid with pungent smell
3	Bhema Tikari	1.1	8.0	0.5	7.7	12730	Blackish and highly turbid with moderate Pungent smell
4	Karan Khal	1.3	8.5	0.7	7.2	12570	Blackish and highly turbid with light pungent smell
Ground water sources							
1	Jheel (U/s of Gajraula industrial area)	-	7.2	-	7.2	722	Colorless and smell free
2	Gajraula industrial area	-	6.9	-	7.7	1720	Dark yellow and smell free
3	Tigri Khadar	-	6.9	-	7.1	746	Light yellow and smell free
4	Karan Khal	-	7.1	-	7.7	817	Slight yellow and smell free

Fig. 2: Level of fish mortality in Bagad River



Physico-chemical analysis:

The physicochemical characteristics of the test water are presented in Table 3. The pH values ranged from 7.2 to 8.5. The dissolved oxygen (DO) ranged from 0.2 -1.6 mg/l. Conductivity level of ground water ranged from 11250 to 12730 µmhos/cm.

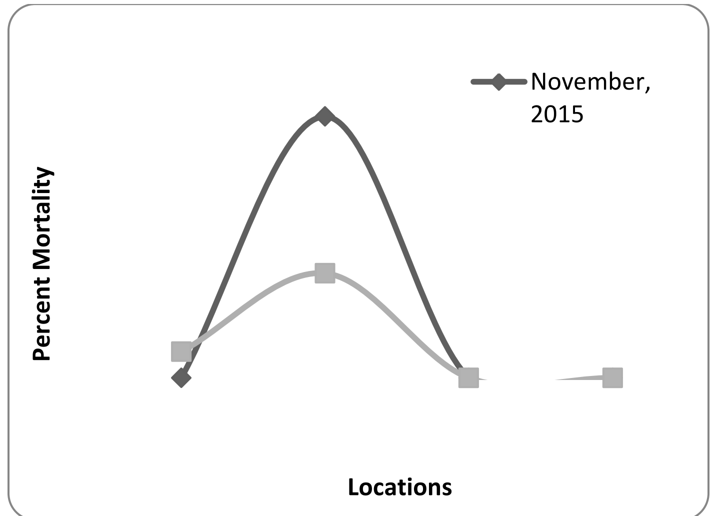


Fig. 3: Level of fish mortality in ground water sources near Bagad River.

Discussion:

Test results of first round of study reflect significantly high level of toxicity at all the locations of studied river stretch with 100% mortality within 15 minute to 6 hours. Slight and gradual reduction in the severity of this eter was noticed on the basis of time taken by the test to reflect mortality of all exposed test organism. Second round of study reflected fish mortality in the range of 40-60% only. This variation, especially in second round, might be due to fluctuation in the quality/quantity of the effluent received by the river on different time period and movement of different batches of water with different quality from U/S to D/s. The occurrence of said variations in the industrial effluent was also verified by the farmers/ villagers. There was no freshwater available in the Bagad so it is like drain carrying mainly industrial effluents. Therefore, in the absence of bioassay standard for river water, the findings of present study are compared with the standards for discharge of environmental pollutants [E(P)A, 1986] i.e. 90% survival of fish after 96 hours in 100% effluent (wastewater) sample. The comparison reflects violation of bioassay standard at all the river locations in both round of studies. Negligible flow in the entire studied river stretch leads to higher retention time but no significant change in the level of toxicity at all the river locations indicates high persistence of toxicants present in the river. Fish bioassay monitoring of waste effluents gives a direct assessment of acute waste toxicity (Schalie et al., 1979). The acute toxicity to fish of four prairie pulp mill effluents was determined as part of a larger project conducted to obtain information on bioassay procedures (Loch J.S. and MacLeod, 1973). Bioassay has been and is being used as a means of measuring the effects of an effluent toxicant upon fish and aquatic animals (Sarakinos and Rasmussen, 1998).

Among the physico-chemical parameters pH was ranged from 7.2 to 8.5 in both rounds of study and meeting the primary water quality criteria for various uses (CBP&CWP, 1984). Its value during first round was slightly high as compare to second round. DO in the entire studied river stretch was found at critical level (0.2 -1.6 mg/l) and thus violates primary water quality criteria for various uses of river water. This low DO indicated presence of high biodegradable organic waste. Inorganic chemicals such as Hydrogen sulfide, Nitrite, Ferrous ion and certain oxidizable material are also responsible for decreasing DO in water (Srivastava *et al.*, 2011).

Conductivity also supports high toxicity in the Bagad River. Its value in river water samples varies from 11250-12730 µmhos/cm and as such not meeting the criteria (2250µmhos/cm) prescribed for lowest class of water (Class E) i.e. water for irrigation, industrial cooling and control waste disposal (CBP&CWP, 1984). High conductivity (11320 µmhos/cm) in the river water clearly reflects impact of industrial effluents. Industrial effluent with high conductivity exerts severe impacts on water bodies globally (Mathuthu *et al.*, 1997).

Color and smell of the collected river samples also indicates heavy pollution in Bagad River. Water quality assessed in the month of October, 2015 at Delhi – Moradabad Highway also reflects high pollutions in the river in terms of Chemical Oxygen Demand (2650 mg/l), Biochemical Oxygen Demand (1700 mg/l) and Suspended solids (428 mg/l). DO in bioassay test sample was generally observed below 4.0 mg/l even after controlled aeration indicating high biodegradable organic matter in river water. Low DO in river water was not directly responsible for fish mortality in test sample as fish mortality was noticed high in first round of study when DO level was generally found high, whereas, in second round, when mortality was less, DO was also found less. It was observed by authors in previously performed tests with the sample with high biodegradable material that Zebra fish can survive in very low DO concentrations (about 0.5 mg/l) may be due to the ability of fish to breath in air also. All this reflects that low DO alone is not responsible for fish mortality.

The ground water samples collected from bore wells near Gajraula industrial area were found toxic with 40-100% mortality of test organisms. Collection of sample from different borewell due to non-operation of borewell sampled earlier might led this variation in mortality as boring depth and distance from the river bank was not same. Mortality in ground water at Jheel, selected as reference was in the range of 0-10%. The ground water samples collected from remaining two loctions were not found toxic on both the occasions. It is to mention here that village is located on the bank of Bagad River but due to poor ground water quality there was no hand pump in the village. The only hand pump in nearby area selected for study was located about 500 meters from river bank.

Conductivity level of ground water 722 (at Jheel, U/s of Gajraula industrial area) - 1720 µmhos/cm (at industrial area) clearly reflects impact of Bagad River. Smell free and color less water at Jheel also indicates that ground water at this site is not affected by the river. However, dark yellow color of ground water near Gajraula industrial area indicates deterioration in its quality. At remaining two studied locations though the water is smell free but light yellow color reflects impact of Bagad River. DO level during bioassay test in the samples collected from Jheel was observed comparatively high (4.4-7.7 mg/l) than the samples collected from bore wells at Gajraula industrial area (1.0-6.8 mg/l) which is also an indication of impact of river water on ground water. DO in ground water samples of Gajraula industrial area, similar to river water, was often found below 4.0 mg/l during bioassay test even after controlled aeration.

Ground water at Jheel was not expected to exert any toxic effect this is because at this site conductivity was low, water was colour less, and impact of industrial effluent was not reported by villagers and its water is used for drinking purpose and variation in DO during test was also less. Still 10% mortality on initial day of test in the second round of study at this site might be attributed either by some infection or injury caused to test organism during exposure in the test sample.

High toxicity in Bagad River water reflects that the effluent that joins river is either untreated or not treated properly. The problem is aggravated further due to non-availability of sufficient fresh water in the river to bring down the concentration of toxicants to safe level. There is possibility of flushing of accumulated toxicants in the river during heavy rain fall or during onset of monsoon, which may severely affects aquatic life of receiving water body i.e. Ganga River. Impact of river water on ground water acquirers was clearly visible through the study. Though, acute toxicity was not observed at D/s ground water locations but chances of chronic toxicity are there. Deterioration in ground water quality is more serious and cause of concern as compared to river water as its restoration process is very slow that require long period of time. Since ground water was extensively used for irrigation on the banks of Bagad River, thus there are chances of transfer and bio-magnification of toxicants that may exerts more severe effects on human and animals.

The result of the present study indicate that the high toxicity in Bagad River water and its impact on ground water bodies, there is an urgent need to check the unabated discharge of industrial effluent by adopting reduce and recycle approach and ensuring proper treatment of effluent. Level of toxicants in the crop irrigated with ground water especially at Gajraula required to be assessed and if found beyond safe level, use of ground water for irrigation should be prohibited.

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