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Comparative index for water pollution by rural and urban means

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Abstract
Over past few decades water pollution has become an issue of worldwide major concern. Availability of fresh water is decreasing gradually as water resource being limited and unevenly spread throughout the globe. Water pollution assessment and development of new and effective waste water treatment methods has become new a line of wide scope in scientific world. Meanwhile, with reference to past studies, we are well aware about the urban pollution that our crowded cities cause by dumping human excreta, household and industrial waste into river bodies but a question arise what is the contribution of rural area and agricultural activities in contaminating river bodies? And is the level of pollution due to agricultural and rural activities is significant with respect to urban pollution? Here we need to take account of biological processes such as bio-magnification and accelerated eutrophication that is caused by direct discharge of agricultural water containing chemical fertilizers and plant growth boosters during irrigation of agricultural field. A study has been conducted by us that involved, collecting water samples of river Rispana and river Bindal from area where agricultural activities are conducted and from areas of crowded city. We ran test like pH, pOH, conductivity, hardness, total dissolved salts, biochemical oxygen demand and chemical oxygen demand to estimate quality of water samples and results were compared as rural *vs.* urban pollution index.

Keywords: Bio-magnification, accelerated eutrophication, pesticide, pollution

Introduction
In past few decades the use of chemical based pest controllers and plant growth supplements is on significant rise. [1] These chemicals are known to drain out from agricultural fields and contaminate water bodies. Is this pollution by agricultural fields that leads to bio-magnification and accelerated eutrophication [2] is more dangerous than the urban pollution? We tried to find out the answer in our study. The planet Earth is also known as blue planet [3] because 71% of Earth's surface is covered by water while only remaining 21% is terrestrial land. Although water is widely available on our planet but still water is a nonrenewable resource which is constant launder threat due to environmental pollution [3]. About 97% of available water is ocean water that supports marine life but it is not suitable for human and animal consumption as it consist of 35g/L of dissolved salt and its pH lies between 7.5 to8.4 [4]. The rest 3% of water source is fresh water [5] which is suitable for human and animal consumption, it consist significantly very less amount of dissolved salt as compared to ocean water and its pH lies between 6.8 to 7.2. But it is unevenly distributed and hence become issue of major concern scientifically, socially as well as politically. Further, use of pesticides is in modern agriculture, disposal of urban waste in natural water bodies, disposal of untreated industrial waste in natural water bodies etc. has now became threat to available drinking water source. In this study we took a deeper look on effects caused by use of chemicals in agriculture with respect and analytical comparison with effects caused by urban waste. The chemicals used in agriculture are generally pesticides, which are substances that are produced to control pests, including weeds [6]. Most pesticides are serve as plant protection products which protect plants from weeds, fungi, or insects. The most common pesticides are herbicides which account for approximately 80% of all pesticide use [6]. In this study we collected water samples of river Rispana and river Bindal from agriculture fields they passes through assuming that the indicated pollution will be majorly due to presence of agriculture based chemicals i.e. pesticide based impurities and we collected water samples from urban city they passes through assuming the indicated levels of pollution will be because of urban waste released into water body.

Test like pH, pOH, conductivity, hardness, total dissolved salts, biochemical oxygen demand and chemical oxygen demand were conducted and results were evaluated [7-9]. Environmental pollution is described as contamination of environment with harmful wastes known as pollutants or contaminants which mainly arise from human activities [10, 11]. Types of pollution include natural pollution which is caused by the natural sources, for example volcanic eruptions, release of methane by paddy fields and cattle, forest fires etc. On the other hand, second type of pollution is man-made pollution which results from human activities like burning of the fuels, deforestation, industrial effluents, pesticides etc. As mentioned above pollution is caused by pollutants which are described as substances produced either by a natural source or by human activity which causes adverse effect on the environment. Classification of pollutants can be done on the basis of their degradation; in this category we study biodegradable pollutants, the pollutants capable of being degraded by biological or microbial actions, for example domestic sewage. The biodegradable pollutants are less harmful but yet play key role in agriculture based pollution.

Whereas we study non-biodegradable pollutants which are the substances which are normally not acted upon by microbes. These undergo biological magnification and hence cause adverse effect to water bodies, plants as well as animals [10, 11]. Classification of pollutants is also done on the basis of their occurrence, under this we include primary pollutants which are present in same form in which these are added by man, for example DDT, pesticides, fertilizers etc. And we include secondary pollutants which occur in different forms and are formed by the reaction between the primary pollutants in the presence of sunlight, for example HNO3, H2SO4 PAN, ozone etc [10, 11].

The contamination of water bodies by foreign substances which would constitute a health hazard and make water source unfit for all purposes (domestic, industrial or agriculture etc) is known as water pollution. The polluted water may have foul odour, bad taste, unpleasant colour etc. [7, 10, 11]

Sources that results water pollution widely include domestic sewage (that is water discharge from kitchens, baths, etc.) and industrial water discharge (that is wastes from manufacturing processes which includes acids, alkalis, pesticides, insecticides, metals. fungicides etc.) Other sources include oil from oil spills or washing of automobiles; Atomic explosion Processing of radioactive materials; Suspended particles (organic or inorganic) viruses, bacteria, algae, protozoa etc.; Wastes from fertilizer Industries such as phosphates, nitrates, ammonia etc.; Clay Ores, minerals, fine particles of soil [7, 10, 11].

Some common examples for effects of impurities in drinking water that influence day to day life includes - Fluorides Mottling of teeth enamel, above 1 mg/L fluoride causes fluorosis, Sulphates of Na, K, Mg cause diarrhoea; Lead It damages kidney, liver, brain and central nervous system; Cadmium and mercury They causes kidney damage; Zn It causes dizziness and diarrhoea; Arsenic It can cause cramps an paralysis; Phosphates from fertilizers They promote algae growth and reduce dissolved oxygen concentration of water. This process is known as eutrophication [7, 10, 11]

Detection of Water Pollution

In order to detect water pollution following tests are known

pH	The test indicates acidity of water sample. Acidity basically represents the presence of H^+ ions in the water sample. Higher the concentration of H+ - higher will be the acidity. Acidity makes water unfit for consumption. pH is temperature dependent phenomenon [7-9].
Conductivity	Distilled water is non-conducting in nature under standard conditions of temperature and pressure. But if impurities are present, they produce ions which make water conducting towards electricity. Grater the dissolved impurities grater will be the value of conductivity [7-9].
Hardness	Hardness is due to presence of Calcium salts. These salts make water unfit for consumption as well as unfit for certain use like washing clothes etc. These dissolved calcium and magnesium salts cause stones in kidney and major disturbance to ion balance in animal and plant metabolism [7-9].
Total Dissolved Salts& Total Suspended Salts	Different waste consist different salts both organic and inorganic. High TDS level indicates presence of huge variety of dissolved salts. It also results in high conductivity [7-9].
Dissolved oxygen	Represent the amount of oxygen dissolved in water sample in terms of mg/L [7-9].
Biochemical oxygen demand	BOD indicates the amount of oxygen consumed by microbes to engulf all organic matter present in specific amount of water. High BOD indicates high level of organic pollutants [7-9].

Materials and Methods

This study is conducted involving basic laboratory devices such as pH meter, conductivity meter, TDS kit, incubator, titration kit, BOD bottles, beakers, funnels, measuring cylinders and test tubes. Method of our research involved selection of suitable locations in rural area and in urban area, collection of samples from all sites, performing analytical tests, evaluation of results and drawing fair conclusion based on obtained results.

Selection of Location: Doon Valley is an atypically wide and long valley in the Shivalik Hills situated in the Himalayan belt at Indian state of Uttarakhand. The valley is fully blessed with fresh water; it has the Yamuna River and the Ganges river running parallel and closest to each other as they pass from the Doon valley. The Shivalik Hills further runs to Himanchal Pradesh and Haryana, two mores states neighboring Uttarakhand. Within this lies the capital of Uttarakhand called as Dehradun which is surrounded on all sides by mountains. It has a northern range called Kalsi in the west direction that runs towards east to Muni Ki Reti having small hill town called Mussoorie at the centre. Also it has a small hilly southern range running from Paonta Sahib in Himachal Pradesh that runs all way towards district Haridwar in Uttarakhand.

We conducted our study analyzing the Song river which is a river in district Dehradun that nourish land at the central and eastern part of the Doon Valley. The Song river is a tributary of Sooswa river, which itself is a tributary of the Ganges river. The Song river it originates as spring-fed stream in the southern slopes of the Radi Top of Mussoorie ridge of the Himalayan range and runs from Dhanaulti towards Narendranagar [12]. Apart from The Yamuna and the Ganges, the Song river is the largest seasonal river that drain the Doon

Valley traversing 190 km of land and having tributaries including, Kali Gad, Shahastradhara, Assan River and Rispana River [13].

We identified two smaller tributaries of the Song river namely, Rispana Rao and Bindal Rao. We identified two sites for each of these tributaries, one at rural area where only agricultural activities are conducted within 2km radius for both rivers and one site where household or micro or medium scale industrial activities are conducted within 2km radius. As the entire district is geographically regarded as hilly, only small scale agricultural activities are observed in which majority of farmers cultivate basmati rice. Similarly only micro or medium scale industries are identified, no particular chemical draining industry was found.

While selecting sites to collect rural area samples we took some key points into consideration. We made efforts to analyse population distribution in the district. Table below represent population variety in district Dehradun -

Table below represent population variety in district Dehradun

Total Population	1025.68 thousands
Urban Population	515.48 thousands
Rural Population	510.20 thousands
Urbanization	50.26 %

The rural - urban ratio lays approximately 50-50 percent. So we identified villages with least population density and maximum possible agricultural activities. Low population densities eliminate possibilities of pollution due to domestic waste and sewage and hence we can get precise data on pollution caused by drainage of agricultural chemicals into rivers because of over or nonprofessional irrigation.

While selecting locations to collect samples from urban area we took sewer and drainage system of Dehradun city in our consideration. Meanwhile the Dehradun city works on natural drainage due to hilly condition. The system is sufficient to drain out storm water easily in to two main natural drainage channels which are our rivers on concern the Bindal and the Rispana. Both the Bindal and the Rispana carry out storm water but condition of rivers are worsen mainly due to dumping of garbage including plastics that is resulting in serious reduction in water path of both the main drainage channels. Studies show that in the old city areas, space for construction of roadside is unavailable. Even 60% to 70% of the houses which do not have a sewer connection or a septic tank they discharge their toilet waste into the existing drains, causing serious environmental problems [14]. For identification of rural pollution village Raipur (northern-middle), range Thano (northern-east), village Nalapani (northern-middle) and range Malsi (northern-west) were selected as collection locations. Whereas for identification of urban pollution, we collected samples from Haridwar-bypass(slightly towards southern-middle) and Kanvli (city center). Samples were collected with assumption that the indicated pollution will be majorly due to presence of agriculture based chemicals i.e. pesticide based impurities at samples collected from village Raipur (northern-middle), range Thano (northern-east), village Nalapani (northern-middle) and range Malsi (northern-west)and the indicated levels of pollution will be because of urban waste released into water body from samples collected from Haridwar-bypass(slightly towards southern-middle) and Kanvli (city center).

Collection of sample, using 300mL collection BOD bottles, two samples (300mL each) of river Rispana and river Bindal were collected at source and two samples (300mL each) of river Rispana and river Bindal were collected at city. We collected water samples of river Rispana and river Bindal from agriculture fields (source of river) they passes through assuming that the indicated pollution will be majorly due to presence of agriculture based chemicals *i.e.* pesticide based impurities and we collected water samples from urban city (Dehradun city area) they passes through assuming the indicated levels of pollution will be because of urban waste released into water body.

Satellite view of Dehradun city located in Doon valley

Satellite view of River Rispana at sources

Satellite view of River Bindal at sources

Performing pH test, apparatus used for the determination of water pH were: pH meter that is suitable for field analysis, distilled water, standard buffer solutions with pH of known standards, thermometer and glass stirring rod. Procedure we followed was - the water sample is properly mixed and stirred using a glass rod. By using a watch glass, sample of water equal to 40ml is added to the beaker. The temperature of the water is allowed to stabilize by placing the sample stand for 1 hour. The standard solutions are used to standardize the pH meter. Next, into the water sample, the electrodes are inserted. The beaker is turned and adjusted so that there is good contact between the electrodes and the water. The apparatus was maintained after each use. The electrodes used are washed thoroughly with distilled water. If there is any form of film around the electrodes, it was be cleared. Wiping of the electrodes must be avoided as this will result in polarization which will result in slow response of the experiment.

Performing conductivity test, apparatus used for determination of conductivity of water were: conductivity meter with electrode, standard flask, measuring cylinder, beakers, funnel and tissue paper. On the other hand, the chemicals used were potassium chloride and distilled water. The procedure followed involves - 0.1Npotassium chloride solution was used to standardize the conductivity meter. Electrode was washed and cleaned using distilled water. Electrode is well dried using tissue paper. Measured 200mL of water sample and transferred into clean and dried beaker. Electrode is dipped into water sample and a 15 min hook was made. Then fixed value of conductivity was noted in micro S cm-1.

Performing test to estimate biochemical oxygen demand, 2ml of manganese sulfate was added to the BOD bottle carefully by inserting the pipette just below the surface of water to avoid the formation of air bubbles. Add 2 mL of alkali-iodide-azide reagent in the same manner. The bottle was closed and components were mixed. A brownish cloud appeared in the solution as an indicator of the presence of Oxygen. The brown precipitate was allowed to settle out to the bottom. Then 2ml of Conc.H2SO4 was added carefully without forming air bubbles. The bottle was closed and the solution was mixed well to dissolve the precipitate. The bottle is kept in BOD incubator for 5days of incubation. After incubation, titration was done using titrate 50 ml of sample water with 0.025N Sodium thiosulphate to a pale yellow color. Then 2ml of starch solution was added as indicator. So the sample turns blue in color. The titration was continued till the sample gets clear and we noted the readings. The concentration of dissolved oxygen in the sample is equivalent to the number of milliliters of titrant used.

Results and Discussion

Under “Indian Water (prevention and control of pollution) Act 1974” the Ministry of Environment, Forest and Climate Change (Mo.E.F.C), Government of India established the Central Pollution Control Board (CPCB) as statutory organization. The CBCBco-ordinates the functioning of the

State Pollution Control Boards by providing assistance and guidance and also by resolves disputes among states over natural resources. According to Central Pollution Control Board, safe water or wholesome water is defined as the water in which radioactive elements are absent, organic substances are absent, which is free from bacteria, which is aesthetically acceptable and chemically safe. On the other end waste water or polluted water is the one which has radioactive elements present, organic matter present, which contains bacteria, which is aesthetically unacceptable and chemically unsafe. According to Central Pollution Control Board's guidelines the parameters in water quality assessment include physical, inorganic or chemical, toxic metals, organic nutrient and demand, bacteriological, biological and radioactive elements. In our study as our goal was not to find out quality of water with respect to drinking purpose but it was just to identify contribution of rural and urban activities so we mainly focused on analyses of physical parameters such as colour, order, temperature, pH, conductivity, total dissolved solids, total dissolved salts, turbidity, hardness and some organic nutrient and demand parameters such as biological oxygen demand, chemical oxygen demand and dissolved oxygen.

As per Central Pollution Control Board's guidelines for the hardness of water, the sample having hardness from 0 to 60 mg/L is classified as soft; 61 to 120 mg/L as moderately hard; 121 to 180 mg/L as hard; and more than 180 mg/L as very hard. As per the results obtained, samples collected from rural/source of Rispana has hardness 440mg/L and the samples collected from rural/source of Bindal has hardness 445mg/L which exceeds the desired limits. The samples collected from urban/city of Rispana has hardness 1123mg/L whereas the samples collected from urban/city of Bindal has hardness 1203mg/L which excessively exceeds the limit. Comparative index shows, 683mg/L addition in hardness when Rispana stream reaches from rural/source to urban/city. For Bindal 758mg/L hardness is added as the river stream reaches from rural/source to urban/city. Hence data indicate very less significance of agricultural activities into hardness of water.

As per Central Pollution Control Board's guidelines for the total dissolved salts in water, the sample having value 500mg/L max will fall in category A', while sample with value 500<mg/L to 1200mg/L will be category B', then 1500mg/L max will be category C'. All of our samples fall in category B' that means based on Total Dissolved Salts water is analytically suitable for external bathing. The total dissolved salts value for rural/source sample for Rispana is found to be 594mg/L whereas he total dissolved salts value for rural/source sample for Bindal is found to be 485mg/L. The total dissolved salts value for urban/city sample for Rispana is found to be 634mg/L whereas the total dissolved salts value for urban/city sample for Bindal is found to be 514mg/L. Although all our analytical results indicate pollution under controlled level but still there is minute difference in total dissolved salts found in samples collected from rural/source and samples collected from urban/city. Hence we may conclude significant role of rural activities towards total dissolved salts found in water.

As per Central Pollution Control Board's guidelines for the pH of water, the ideal pH value for A' to E' category water falls between minimum 6.5 to maximum 8.5 on standard pH scale at standard temperature. All our samples indicate excessively high acidity in the water sample. According to pH values the water at rural/source as well as the water at urban/city is highly acidic and not suitable for use. We can observe that as Rispana drains from rural/source to urban/city pH drops from 6.3 to 5.7 whereas while Bindal drains from rural/source to urban/city pH drops from 6.1 to 5.6. We may conclude highly significant impact of agricultural activities towards making water acidic.

The obtained results indicate high pollution in river bodies that flows through the city. But also reflects pollution at source possibly due to nearby agriculture activities as source of human excreta or household pollution was not observed within 1km radius. Therefore we must spread awareness, collect scientific data about agriculture pollution before it exceeds critical readings.

We collected water samples of river Rispana and river Bindal from agriculture fields (source of river) they passes through assuming that the indicated pollution will be majorly due top resence of agriculture based chemicals *i.e.* pesticide based impurities to establish rural/agricultural pollution and we collected water samples from urban city (Dehradun city area) they passes through assuming the indicated levels of pollution will be because of urban waste released into water body to establish city/urban pollution.

From the above result, it is quite clear that (i) river Rispana and river Bindal both are polluted and water is not suitable for drinking purpose; (ii) samples collected from city area (urban) show higher levels of pollution with respect to samples collected from source (rural); (iii) since samples collected from source (rural) also indicate pollution.

Table 1: Different biochemical and physical properties of samples collected from different sources

Performed Tests	Rispana (source)	Bindal (source)	Rispana(city)	Bindal(city)	Suswa(mainstream)
pH	6.3	6.1	5.7	5.6	6.2
Temp.(^{0}C)	22.1	22.4	22.1	22.4	21.4
Conductivity(micros/cm)	848	851	939	1042	341
Hardness(mg/L)	440	445	1123	1203	180
Turbidity(NTU)	5-10	5-10	25-50	25-50	25-50
Total-dissolved salts(mg/L)	594	485	634	514	178
Total Suspended salts(mg/L)	78	125	97	147	113
Dissolved oxygen(mg/L)	3.0	3.6	2.0	2.8	4.4
Biochemical oxygen demands(mg/L)	3.7	2.7	5.4	6.1	5.3

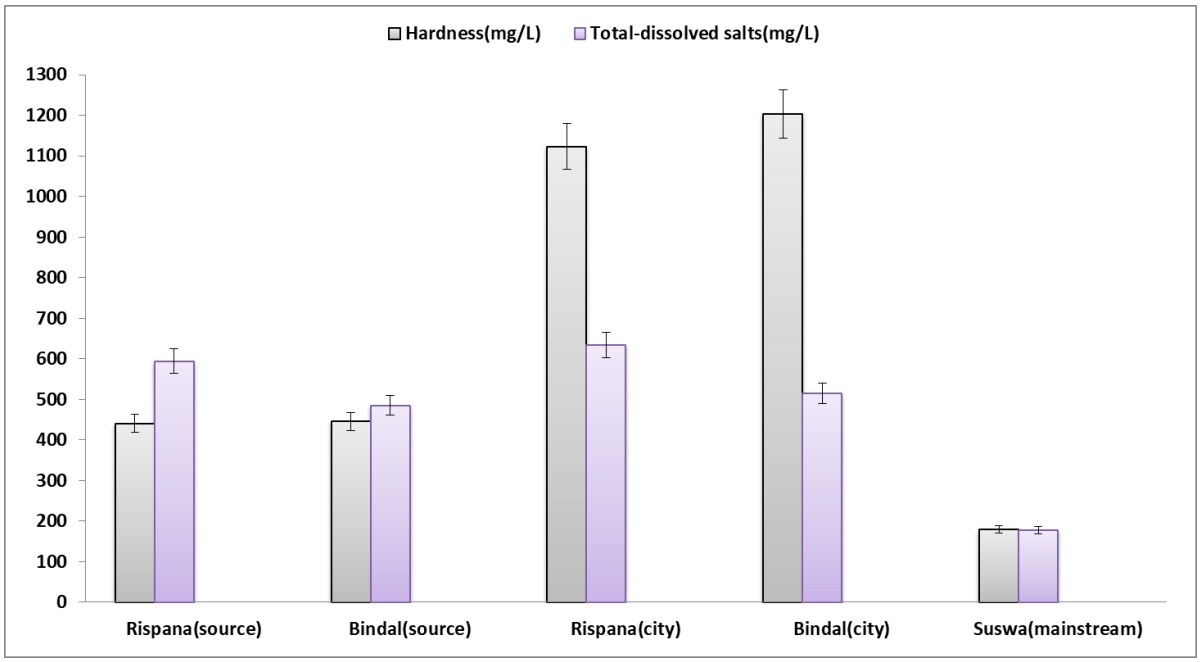

Fig 1: Effects of water pollution on the hardness and total dissolved solids of different sources of water

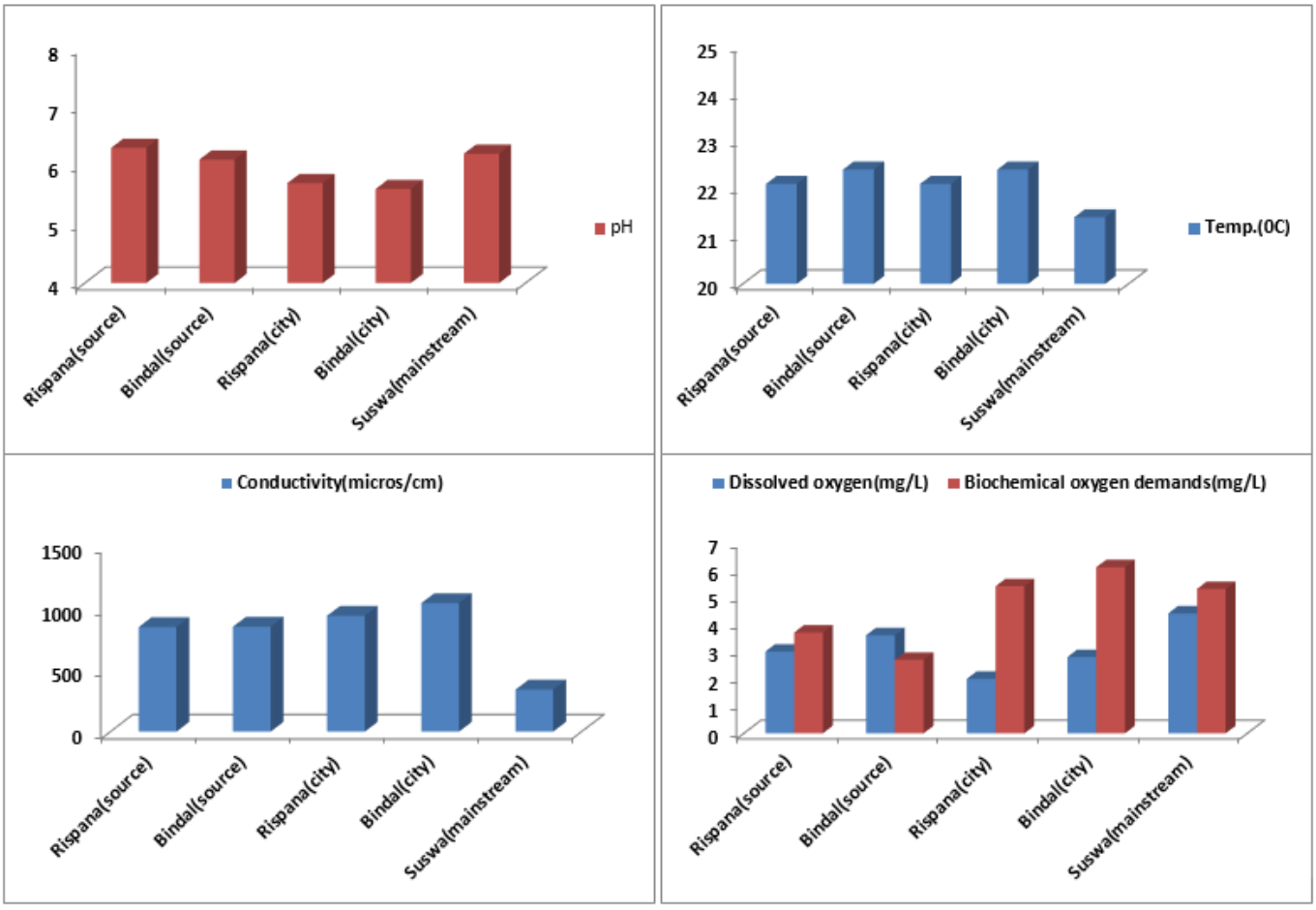

Fig 2: Effects of water pollution on pH, Conductivity, Temperature, Dissolve oxygen and BOD of different sources of water

As per Central Pollution Control Board's guidelines for the conductivity of water, the sample having value less than 1000microS/cm falls under category A' to C' and those having between 1000 microS/cm to 2500microS/cm will fall under category D' or category E'. Accept urban/city sample of Bindal river with value 1042microS/cm that falls in category D' all other samples fall in category C'. Conductivity is particularly due to presence of ions that means higher the concentration of ions, higher will be the conductivity. Results indicate that as Rispana drains from rural/source to urban/city conductivity rise from 848microS/cm to 939microS/cm whereas while Bindal drains from rural/source to urban/city conductivity rise from 851microS/cm to 1042microS/cm. We may conclude highly significant impact of agricultural activities towards making water more conductive.

Maximum solubility of oxygen in water is 3mL/100mL, higher the amount of dissolved oxygen, better is the quality of water sample. As per Central Pollution Control Board's guidelines for the dissolved oxygen in water, the sample having value 6mg/L falls in category A', while the sample having value 5mg/L falls in category B', whereas the sample having value 4mg/L falls in category C' or D' and the sample having value less than 4mg/L will fall in category E'. The dissolved oxygen level of rural/source of Rispana is 3.0mg/L whereas he dissolved oxygen level of rural/source of Bindal is 3.6mg/L. On the other hand the dissolved oxygen in urban/city of Rispana is 2.0mg/L whereas the dissolved oxygen in urban/city of Bindal is 2.8mg/L. Based on guidelines, all our samples were found polluted and having extremely low dissolved oxygen level that makes them unsuitable for drinking as well as unsuitable for aquatic life.

Bio-chemical oxygen demand represent the amount of oxygen that bacteria present in water will consume during consumption or degradation of organic matter present in 1000mL of water sample. Higher bio-chemical oxygen demand means higher presence of organic matter. And higher the concentration of organic matter, higher is the pollution. If bio-chemical oxygen demand of water is less than the amount of dissolved oxygen only then water is useful otherwise it become polluted and unsuitable for drinking or to support aquatic life. Our analytical results indicate high level of bio-chemical oxygen demand in all the samples. The level of dissolved oxygen at rural/source of Rispana is found to be 3.0mg/L where the bio-chemical oxygen demand was found to be 3.7mg/L which makes water of Rispana under threat at rural/source. The level of dissolved oxygen at rural/source of Bindal is found to be 3.6mg/L where the bio-chemical oxygen demand was found to be 2.7mg/L which makes water of Bindal suitable for use at source. Whereas the level of dissolved oxygen at urban/city of Rispana is found to be 2.0mg/L where the bio-chemical oxygen demand was found to be 5.4mg/L which makes water of Rispana to be under extreme threat. And the level of dissolved oxygen at urban/city of Bindal is found to be 2.8mg/L where the bio-chemical oxygen demand was found to be 6.1mg/L which too makes water of Bindal to be under extreme threat.

Conclusion

From obtained results it quite clear that both the rivers are polluted at city (urban) as well as at source (rural). Pollution level is comparative for both the samples collected from city (urban) and collected from source (rural). One can observe only a slight difference between pollution levels that indicate significance of pollution caused by agricultural activities in rural areas which is also carried to river stream at urban city where due to household sewage and industrial dump pollution level rise further. Based on results, it can understand the significance of understanding agriculture based pollution and one can understand the need to identify and implement methods to prevent agriculture based pollution before it reaches higher level.

Further, rural or agricultural activities are found to be a significantly contributing factor towards the pH level, conductivity and especially towards bio-chemical oxygen demand level of samples. One can jump to conclusion that in order to make any river pollution free, we must pay equal level of attention towards controlling agriculture/rural based pollution as we pay attention towards eliminating urban factors that threats the rivers. For example, to clean the river Ganges, we must work on regulating agriculture activities in the villages through which the Ganges pass. As well as we must regulate the urban/industrial dump but if one focus only on eliminating urban/industrial threats then river can't be made pollution free to best possible analytical extent.

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