DISSERTATION

ON

HEALTH ASSESSMENT OF GANGA RIVER ALONG THE MAJOR CITIES, CONTAMINATION IN AGRICULTRAL LAND AND POWER GENERATION TECHNIQUE IN STP PLANTS

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CANDIDATE'S DECLARATION

I hereby declare that the work which is being presented in this Seminar, entitled, "**HEALTH ASSESSMENT OF GANGA RIVER ALONG THE MAJOR CITIES, CONTAMINATION IN AGRICULTURAL LAND AND POWER GENERATION TECHNIQUE IN SEWAGE TREATMENT PLANT (STP)**", in partial fulfillment of the requirement for the award of the degree of **Master of Technology in " Water Resources Development"**, submitted in the **Department of Water Resource Development and Management**, **Indian Institute of Technology, Roorkee, India** under the supervision of **Dr. Deepak Khare, Professor**, Department of Water Resource Development and Management, Indian Institute of Technology , Roorkee, India.

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CERTIFICATE

This is to certify that the above statement made by candidate is correct to the best of my knowledge.

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ABSTRACT

In the study regarding pollution in Ganga River, heavy metals detection test were performed over three major cities located along the stretch of Ganga River, cities are Haridwar, Kanpur and Prayagraj. From the result, it was observed that the two elements Calcium (Ca) and Magnesium (Mg) were found within the permissible limit in the test. Hence Ca and Mg were not considered in the result analysis. The traces of Zinc (Zn) at most of the places were much more than Lead (Pb), Copper (Cu), Cadmium (Cd) and Manganese (Mn), But within the permissible limit. The traces of Chromium (Cr), Iron (Fe), Selenium (Se) and Arsenic (As) were exceeds the permissible limit (IS 10500). The traces of elements in Kanpur samples were such as Cr 0.02-0.98 ppm, Fe 1.9-2.3 ppm, Se 1.8-2.3 ppm, As 3.8-4.2 ppm. In Prayagraj, the concentration of Cr is less than the Kanpur, but it can be observed from the graph traces of other elements like Fe, Se, and As were high. Their ranges are such as Cr 0.01-0.04 ppm, Fe 3.6-8.2 ppm, Se 1.5 ppm, As 5-5.5 ppm. The traces of different elements in Kanpur as shown such as Cr 0.48 ppm, Fe 3.48ppm, Se 1.8 ppm and As 6.4ppm.In Prayagraj, the traces of elements as shown fig. 5b at different points are, at upstream Cr 0.01 ppm, Fe 5.12 ppm, Se 1.0 ppm, As 8.71 ppm. At confluence point Cr 0.1ppm, Fe 0.93 ppm, Se 1.16 ppm, As 4.52 ppm. At downstream point Fe 3.08ppm, Se 0.96ppm and As 6.04ppm. Presence of such toxic elements in Ganga River can cause an adverse effect on human health as well as the ecosystem of the river, Environmental condition, and Industries. Fe, Se, and As are the elements, Having exceeded value is very at most of the place. The exceeded value of elements such as Fe 7.9ppm, Se 1.49ppm and As 5.4ppm. In second objective tells about the agricultural Land contamination of the Jajmau area in Kanpur Uttar Pradesh to find out the chemical pollution in soil due to industrial waste. The tanning industry in the Jajmau had been established since 1940, now the impact of such industries on the land is a severe threat to human life. The soil sample for three different seasons get collected and stored, After that with the help of leaching process and ICP-MS test, study of metals like Magnesium (Mg), Chromium (Cr), Iron (Fe), Arsenic (As), etc over agricultural field along the banks of Ganga River, namely Jajmau area. The traces of Arsenic (As), Magnesium (Mg) and Iron (Fe) at the study area were much more than Lead (Pb), Copper (Cu), Cadmium (Cd) and Manganese (Mn), Chromium (Cr).The traces of different elements of Soil samples for pre-monsoon are in parts per million (ppm) are such as Cr 0.006-0.01 ppm, Fe 0.38-3.0 ppm, Se 0.7-0.85 ppm, As 25-55 ppm, Pb 0.01-0.25 ppm, Cu 0.005-0.01 and Cd is much less as compared to

other elements. For monsoon season soil sample, the traces of elements are such as Mg 18-94 ppm, As 25-42 ppm, Fe 6-9 ppm, Cr 0.7-1ppm, Se 0.8-0.83 ppm, Cu 0.06-0.07 ppm, Pb 0.02-0.04ppm, and Mn 0.03-0.05ppm, whereas still the traces of Cd presence indistinct amount. Now, for the post-monsoon soil sample, the traces of elements are such as 67-109 ppm, Mg 0.49-32 ppm, Fe 3-46 ppm, Cr 0.04-3ppm, Se 0.6-1.58 ppm, Cd 0.007-0.29 ppm, Pb 0.012-0.8ppm, Cu 0.1-.4 ppm, and Mn 0.13 ppm. It has been observed that the traces of Arsenic, Iron and Magnesium are much high as compared to other elements. In post monsoon result Fe is much higher as compared to pre-monsoon and monsoon results. Diseases like renal dysfunction, Lung diseases, Kidney and Liver damage, Damage to nerve tissue, Bone disorder, Damage to the central nervous system etc, cause on human life. The presence of heavy metals in soil can reduce crop production, also contaminated the river or lake which in turns destroy underwater ecosystem like the killing of fishes, destroy of aquatic plants etc. We need to identify those industries, which are discharging their effluent directly into the Ganga River and strict action must be taken against them. Power is known as back bone for any developing nation, developing nation like India is still facing issue to full fill the demand of power in some part of the country. Government of India approved 2000 MLD STP projects (under Ganga Cleaning Program) in the cities along the Ganga River. STP plants require uninterrupted power supply for its operation; it is a tough challenge for the government bodies to manage power. On looking to such issue, the idea of power generation techniques in STP plants in the following ways are 1. By placing turbines at outlet channel and constructing small power house inside the plant, 2.Use of Solar panels over the roof area and open land inside the plant premises.

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Abbreviations	Description
FAO	Food and agricultural organization
GAP	Ganga Action Plan
NMCG	National Mission for Conservation of Ganga
STP	Sewage Treatment Plant
O&M	Operation and Maintenance
WHO	World Health Organization
MLD	Million Liter Per Day
UPJN	Uttar Pradesh Jal Nigam
CETP	Common Effluent Treatment Plant
IS 10500	Indian Standard 10500
UN	United Nation
M	Meters
NRCP	National River Conservation Plan
NGBRA	National Ganga River Basin Authority
DNA	Deoxyribo Nucleic Acid
UASBR	Up Flow Anaerobic Sludge Blanket Reactor
KW	Kilo Watt
UASB	Up Flow Anaerobic Sludge Blanket
GLSS	Gas Liquid Solid Separator

NTU	Nephelometric Turbidity Unit
COD	Chemical Oxygen Demand
BOD	Biochemical Oxygen Demand
DO	Dissolved Oxygen
ICP-MS	Inductive Coupled Plasma Mass Spectrometry
EDTA	Ethylenediaminetetraacetic acid
EBT	Eriochrome Black Tea
TSS	Total Suspended Solid
TDS	Total Dissolved Solid
Ppm	Parts Per Million
c/h or C/H	Channel
N	Efficiency
P	Density

Abbreviations	Description
Q	Discharge
H	Net Head
G	Acceleration due to gravity
P	Power
USA	United States of America
MW	Megawatt

1.1 GENERAL

Water is an essential element of human life. Earth comprises 75 percent water, out of which 2-3 percent is fresh water (WHO REPORT). More than one-third of Earth's accessible renewable freshwater is consumptively used for agricultural, industrial, and domestic purposes. Due to an increase in population, accompanied by anthropogenic activities, fresh water is getting deteriorated day by day (Schwarzenbach et. al. 2010). As most of the activities lead to water contamination with diverse synthetic and geogenic natural chemicals, it comes as no surprise that chemical pollution of natural water has become a major issue in almost all parts of the world (Schwarzenbach et. al. 2010). The toxic chemical released by the different industries not only impact on natural habitat but also on the health issue (Zhang et. al. 2011). The issues like health issue started occurring in human life due to different water born diseases and diseases like typhoid cholera jaundice etc (Singh et. al. 2004). Diseases like cancer started due to the carcinogenic compound from industries effluent and domestic sewage as well as aquatic life getting disturbed due to the effluent of heavy industries (Rehana et. al .1995).

Regarding human health, the most direct and most severe impact is the lack of improved sanitation, and related to it is the lack of safe drinking water, which currently affects more than a third of the people in the world. Additional threats include, for example, exposure to pathogens or to chemical toxicants via the food chain (e.g., the result of irrigating plants with contaminated water and of bioaccumulation of toxic chemicals by aquatic organisms, including seafood and fish) or during recreation (e.g., swimming in polluted surface water) (Schwarzenbach et. al. 2010). The sources and impacts of these common classical pollutants are reasonably well understood, but designing sustainable treatment technologies for them remains a scientific challenge.

Industries generating toxic waste not only pollute the river but, also pollute the land and soil. In addition, with soil essential to providing food for 95 percent of the world, soil pollution not only reduces the quantity and quality of crops and produce, but it also worsens poverty and compromises the future for generations to come, warned the head of FAO (UN report 2018). Soil contamination is posing a serious issue to our environment, to our sources of food and ultimately to our health (FAO report May 2018). The Food and agricultural organization of the United Nations (FAO) warns that there is still a lack of awareness about the scale and severity of this threat.

Energy is becoming a lifeline of the developing nation, its role is very important for sustainable development and power allegation. In India and China the energy demand will be increased by 70 percent in the future, the need of this demand not only limited to two But other developing nations will also come in this necessity(Renewable 2011 Global Status report). In India, the central government approved more than 2000 Million Litre Per Day Sewage Treatment Plant (STP) infrastructure along the stretch of river Ganga under the Namami Gange Program (NMCG Annual Report). Previously under Ganga Action Plan Phase I (GAP I) and Ganga Action Plan Phase II (GAP II), the government already constructed many STP's (NMCG Report). But, the operation and maintenance (O & M) of STP plant infrastructure are a big issue for both government and private authorities. The major challenges faced in the previous efforts to clean the river Ganga were lack of ownership, lesser support for the sustainability of infrastructure, and suboptimal performance of the treatment infrastructure created. Now, come to the one phase of the O &M i.e. the electrical expenses of one month for 210 MLD plant is around fifty-five lacs. To overcome the electrical expenses of STP's, the ideas of power generation in the plant, with the help of turbines and Solar panels.

I.2 BACKGROUND OF STUDY

1.2.1 Pollution in Ganga

Due to unique geographical, historical, Social, Cultural and economic importance, River Ganga was declared a national river. It has been facing various types of serious threats like the discharge of excess quantities of sewerage and industrial effluents. "River Ganga" consists of the entire of six head-streams in the state of Uttrakhand namely, Rivers Alaknanda, Dhauli Ganga, Pinder, Mandakini and Bhagirathi starting from their originating glaciers up to their respective confluences at Vishnu Prayag, Nand Prayag, Karn Prayag, Rudra Prayag and Dev Prayag as also main stem of the thereafter up to Ganga Sagar including Prayagraj and includes all its tributaries. States comprising River Ganga basin, namely, Uttrakhand, Uttar Pradesh, Bihar, and West Bengal. "Tributaries of River Ganga" means those rivers or streams which flows into River Ganga and includes Yamuna River, Son River, Mahananda River, Kosi River, Gandak River, Ghaghara River and Mahakali River and their tributaries or such other rivers which National Council for Rejuvenation Protection and Management of River Ganga may, by notification, specify for the purpose of this order.

The Stretch of the river along Kanpur in Uttar Pradesh has been identified as the most polluted due to the discharge of untreated domestic and industrial wastewater. The tanneries located in the Jajmau of Kanpur city on the south bank of river Ganga are the major source of industrial waste being discharged into the river Ganga. Before Kanpur, mainly domestic effluents are being discharged in the Ganga, which is also a serious issue for the NMCG.

1.2.2 Contamination of Agricultural land in Jajmau Area Kanpur

In the Kanpur Jajmau area is well known for the tanning industry, it is situated on the right bank of the Ganga River and on the left Bank its tributary. Jajmau is a chronic polluted area and also known for the biggest exporting centers of tanned leather (Gowd et. al. 2010). The tanneries located in the Jajmau of Kanpur city on the south bank of river Ganga are the major source of industrial waste being discharged into the river Ganga (UPJN report). In the Kanpur Jajmau area known as the center of the tannery industry, the agricultural land in Jajmau got badly contaminated by irrigating through the polluted water supply. The water for irrigation purposes gets supplied from 36 Million Liter per Day (MLD) Common effluent treatment plant (CETP). The CETP plant in Jajmau used to treat mainly tannery effluent after the treatment final effluent from CETP get supplied to agricultural land for irrigation as well as discharged into the Ganga River. Tanning is processed by means of which hides and skins are preserved from decay and converted into an imputrescible substance known as leather (UPJN, Kanpur Report).

1.2.3 Upgradation of STP (Sewage Treatment Plant) through power Generation

Under the Ganga action plan phase I, II and Namami Gange, the government approved the number of projects to develop the sewage infrastructure till now. Presently, under Namami Gange Program is not only focusing on the construction of new STP Plants as well as upgradation already constructed STP plants under GAP I and GAP II. Previously under Ganga Action Plan Phase I (GAP I) and Ganga Action Plan Phase II (GAP II), the government already constructed many STP's. But, the operation and maintenance (O & M) of STP plant infrastructure are a big issue for both government and private authorities. The major challenges faced in the previous efforts to clean the river Ganga were lack of ownership, lesser support for the sustainability of infrastructure, and suboptimal performance of the treatment infrastructure created. The per month electrical expenses for any STP pant is around 25-60 lacs round figure, other maintenance cost not included like repairing of damaged electrical parts. To reduce the operation and maintenance cost of STP plants, the idea of power generation by using turbines at the outlet channel and using solar panels to generate the power and to store it properly. So, that stored power can be utilized in operating the plant.

1.3 PROBLEM IDENTIFICATION

1.3.1 Research Gap

- In the Namami Gange project, the main issue is that still there are some major cities where all drains are not tapped. It means that effluent got discharged directly into the river.
- The eco flow in the river or self-cleansing velocity is not being maintained, due to this natural cleaning of the river not able to take place. (IIT Kanpur Study Report**)**
- In the cities like Kanpur which is known as the hub for the leather industry, they are releasing the effluent having toxic chemicals like chromium, arsenic, lead, etc being disposed into the river and land. The Proper remedies for removal of chromium and heavy metals not being taken (Mwinyihija, M. 2010).
- Effluent from industry (leather industry) getting treated in CETP (Common Effluent Treatment Plant) still having chromium and toxic metals in it. After that treated water is being used for irrigation purposes and directly discharging into the Ganga River.
- Sometimes proper flow in the STP's cannot be delivered, due to which running costs are getting over economical. (Field report).

1.3.2 Objectives

- To test various water quality parameters of the study area (Mid Ganga Basin).
- To detect the presence of heavy metal quantity in the river and match the result much more than the permissible limit as per **IS10500**.
- Contamination in agricultural land.

- To study existing Sewage Treatment Plant system and explore the possibility of Upgradation and evolve STP's energy efficient system.

1.4 STRUCTURE OF THESIS

In the present study covers four objectives and consists of seven chapters. In the various chapters consist of following, In Chapter 1, the general introduction, Background of the study of various objective, problem identification, and structure of the thesis. In Chapter 2, the literature review of three objectives, which is divided into subtopics Pollution in the river, Impact of River Pollution, Measures are taken to clean the river, challenges being faced during river cleaning, Land Contamination issue, Effect of land contamination on food cycle, Remedies and measures taken for land contamination, . In Chapter 3, study areas of three different objectives are being discussed, It covers. In Chapters 4, Study of the Ganga River Health Assessment along with the major cities. In Chapter 5, Agricultural land Contamination. In Chapter 6, Upgradation in STP plants to reduce operation and maintenance cost In Chapter 7, Conclusion from the three different objectives.

2.1 GENERAL

As mentioned in objectives 1.3.2, In this chapter detail discussion of each objective with the help of the research papers related to the study. An overview of the study of different objectives as shown in Fig 2.1

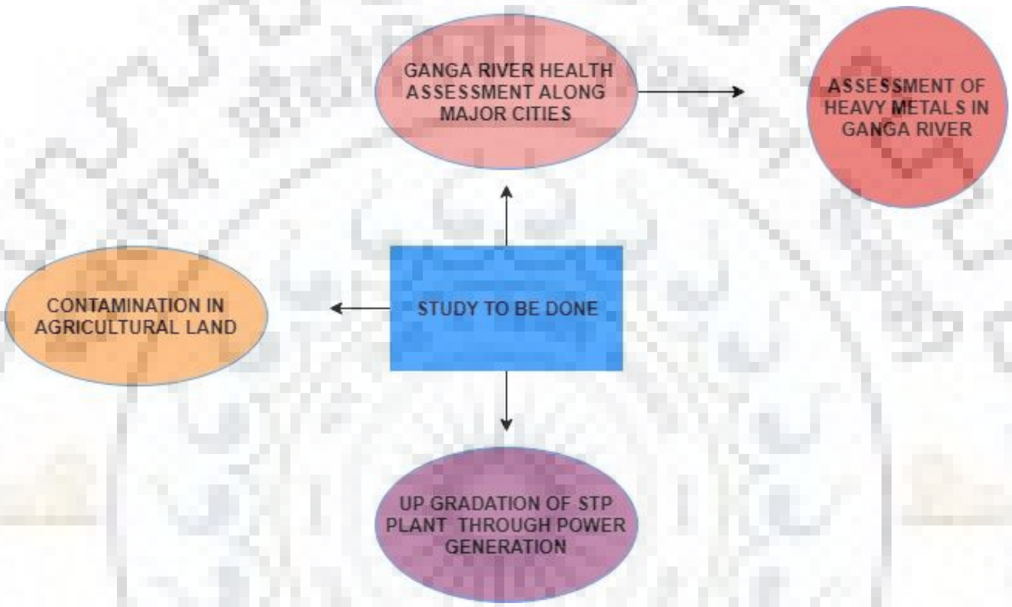


Fig 2.1: General Overview of the study.

The literature review covers the detail discussion of various objectives, Object1: river pollution, Reason for occurrence of pollution in river, River pollution impact on environment, human and aquatic life, Object2: Assessment of Heavy Metals, Object 3: Contamination in agricultural land, Effect of contamination on food chain and Object 4: Upgradation of Sewage Treatment Plant (STP) through power generation with help of turbines and solar panels.

2.2 GANGA RIVER HEALTH ASSESSMENT ALONG MAJOR CITIES

2.2.1 RIVER POLLUTION

In Developing Countries River pollution are one of the major challenges for them, the lack of proper drainage system, the Discharge of domestic and industrial effluent into the river without treatment, and No proper awareness among the people. The main cause of the pollution of various types of chemical, physical parameters, and pathogens, which includes organic and inorganic substances. The various type of industries like tanning, paper pulp, etc is the main cause of river pollution. In countries like China also facing the problem of river pollution due to the rapid development of industries and urbanization(C.S.C Wong et. al. 2002). Still today,80 percent of global wastewater goes untreated, containing everything from human waste to highly toxic industrial discharge(UN environment program report). Other than domestic and industrial effluent, In the agriculture sector also polluting the river. To increase the yield of the crops, Use of different types of pesticides and chemical fertilizers were increased in recent years (http://www.unwater.org). In developing countries, pollution in the river due to agricultural use of untreated or inadequately treated wastewater is the major issue for them.

In India, the main cause of river pollution is untreated sewage water is being discharged into the river. There is the number of sewage treatment plant (STP) constructed in various cities, But due to lack of maintenance of existing STP's are not in working condition (report 2007). Various types of issues being faced in operation of STP's plant are improper design, Lack of proper electricity improper management, etc(report WHO 2007). According to the report major cities in India producing nearly 38,000 MLD of sewage water, But the treatment capacity is only 11,768 MLD of all cities (UN water publisher report).

In this report, I discussed contaminants and pollutants in the Ganga River at three major cities Haridwar, Kanpur, and Allahabad. Sampling had been done from three cities mentioned earlier, three samples collected from each city. From the experimental results, it had been observed that the Kanpur is known as the most polluting city other than two cities. Kanpur is also known for the tannery industry, there are several challenges in tannery wastewater management at Kanpur because of the tanneries located in the Jajmau area of Kanpur City on the south bank of River are the major contributors of industrial waste being discharged into the Ganga River. In Allahabad and Haridwar only domestic effluents are being discharged into the Ganga River. For the case study soil sample collected from the irrigation field at the Jajmau area in Kanpur, the Column test of a soil sample is to be performed to study soil suitability for agriculture.

2.2.2 Impact of River Pollution

Water pollution caused 1.8 million death in 2015 (study by the Lancet). Every year around 1 billion people got sick due to contaminated water. A low-income group of people is mainly affected due to contaminated water.

Various types of waterborne diseases causing bacteria and viruses are mainly from human and animal waste. Water born diseases account for the deaths of 3,575,000 people a year (report by world counts). Different types of water born diseases are Typhoid, Cholera, Paratyphoid Fever, Dysentery, Jaundice, Amoebiasis, and Malaria. Pollution due to the pesticide can damage the nervous system and can cause cancer because of the carbonates and organophosphates that they contain. Chlorides can cause reproductive. Nitrates in water are especially dangerous to babies, It causes the blue baby syndrome. Lead can get accumulated in the body and damage the central nervous system. Arsenic in water can cause liver damage, skin cancer, and vascular diseases. Fluoride in excess amount makes teeth yellow and causes damage to the spinal cord. Petrochemicals in water even with low exposure can cause cancer (report by world counts).

Polluted river is not only dangerous to human life. But, it also causes an adverse effect on the environment too. Industrial effluent contains various type of heavy metals can accumulate in nearby lakes and river. These are toxic to marine life such as fish and shellfish and can affect the rest of the food chain. The toxic compounds from industrial effluent not only harm the aquatic animals but, also disrupt the community structure of an aquatic environment. Infectious diseases from microbial pollutants also disrupt the aquatic life and terrestrial drinking water. Organic matter and nutrients are cause an increase in aerobic algae and deplete oxygen, It is known as eutrophication and causes the suffocation of fish. Sulfate particles from the industrial effluent also affect the health of aquatic human life in the river.

2.2.3 Measures taken to clean the river

There are different types of measures taken to clean the river. Firstly, it is the awareness among the people, who are supposed to live along the river. People must be aware of the proper drainage system for generated wastewater from household activities, Sewage water must be properly treated before it gets discharged into the river.

Secondly, one of the biggest problems with water is transboundary nature. Many rivers cross countries, while seas span whole continents. Pollution discharged by factories in one country also affects the neighboring nation. Environment law can make it tougher for people who pollute, but to be really effective across national and international borders, That's why international laws were made in 1982 UN Convention on the law of the Sea, 1976 Bathing water directive (updated 2006),1972 Clean Water Act and Safe drinking water act(Woodford, Chris. (2006/2019)Water Pollution. In India, also number laws were passed to control and prevent water pollution Water Prevention and control of pollution act,1974,Orissa river pollution act,1953, Water prevention and control of pollution cess act,2003 for industrial effluent disposed in to the river, The River Boards Act,1956 for establishment of rivers and the regulation of interstate water disputes.

Thirdly, the Volume of wastewater flow that is either flow transferred to a sewage treatment plant (STP), where they are treated in compliance with national local standards.28 out of 79 countries are based on reliable performance data that reflect whether the treatment is complying with national or regional standards and the remaining 51 countries are based on treatment data (UN water report on Progress of wastewater treatment plant). Within Europe, treatment plant performance is generally above 80 percent; however, treatment performance as low as 20 percent indicates some treatment plants were not functioning due to poor operation and maintenance (UN water report).

In India, 1980 the first step towards to clean Ganga was taken. In an earlier stage of the Ganga action plan is based on abatement of sewerage pollution as the focal area of cleaning river Ganga. Various types of schemes by the government for Ganga cleaning are the Ganga Action Plan (GAP-I), GAP-II, National River Conservation Plan (NRCP), etc. These schemes are either be non-functional or failed due to improper management. On 2008 Ganga declared as a national river, followed by the constitution of the National Ganga River Basin Authority (NGRBA) in 2009. On 20 February 2009 under section 3 of the Environment (Protection) Act, 1986 as an empowered planning, financing, Monitoring and coordinating authority for the Ganga River. On 12th August 2011, NMCG (National Mission for Clean Ganga) registered as under the society registration act 1860, to act as an implementation arm of NGBRA. Next major development in the evolution of NMCG was lunch of Namami Gange Programme on 13th May 2015 with approval of cabinet as central sector scheme (100 percent central assistance), with component including all objectives of NGBRA. The Namami Gange program has been on abatement of pollution together with cleaning of Ghats, Regulatory control of industrial pollution and real-time online monitoring of pollution in the river.

2.2.4 Challenges and Issues in river cleaning

There are many challenges are being faced today in the cleaning of river, first one is a discharge of sewage wastewater, a Large number of drain bigger size and smaller size drains from the various cities along the river. In the Ganga river cleaning project, still, there are the number of drains remains untapped. Drains are mainly of two types domestic discharge effluent and industrial discharge effluent. Domestic sewerage consists of sewerage water from household areas, schools, hospitals, etc. Industrial effluent means discharge of effluent from a different type of industries like Thermal power plant, Textile industries, Tanning industries, etc.

In the rural area along the stretch of Ganga River, the major issue is the open defection near the bank of the river. Due to lack of awareness among the people living in rural, such a problem of open defecation is still a major issue in the cleaning of the river.

According to the Namami Gange action plan, the Government has passed a number project for the construction of a new sewage treatment plant (STP) or to increase the capacity of existing STP's. But, still, there is a number of STP's projects remains incomplete. Hence, Sewage waste water is being discharged into the Ganga River without any type of treatment. There are many STP's projects still remains incomplete, it takes more time to complete the construction work. As per Namami Gange targets with over 2000 Millions Liter per Day (MLD) had to be rehabilitated of which only 328 MLD have been done. 68 projects were sanctioned after the Namami Gange Project was approved by cabinet only six were completed till August. The main reason behind for projects is being delayed because of Land acquisition and other related activities.

Excessive sand mining from the river results in the degradation of the river bed, which results in the natural filtration mechanism of the river gets deteriorated.

2.3 CONTAMINATION IN AGRICULTURAL LAND

2.3.1 Soil Contamination Issue

The presence of elements in soil across the excessive limit results in contamination of land.

Contamination is defined as Soil pollution refers to the presence of a chemical or substance out of place and/or present at a higher than the normal concentration that has adverse effects on any non-targeted organism. Soil pollution often cannot be directly assessed or visually perceived, making it a hidden danger" states the FAO report. As a "hidden danger" right below our feet, soil pollution turns out to be underestimated affecting everyone – humans and animals.

The FAO report warns that this “dangerous phenomenon should be of concern worldwide. Contamination consequences are not limited to the degrading of our soils: ultimately, it also poisons the food, the water, and the air. Soil pollution significantly reduces food security, not only by reducing crop yields due to toxic levels of contaminants but also by causing crops produced from polluted soils unsafe for consumptions both for animals and humans. In developing countries like India, disposal of industrial effluent with proper treatment is one of the major challenges for the authorities (Gowd et al.2010). Metals such as Zn, Cu, Se, Mg, Mn, As, Pb and Cr are within permissible limit beneficial to vegetables, crops, plants and human life (Sharma et al. 2006). However, the presence of such elements in an excessive amount becomes toxic. The accumulation of heavy elements in crops and vegetables more than the permissible limit has an adverse impact on human health and plants. However, the presence of such elements in an excessive amount becomes toxic. The accumulation of heavy elements in crops and vegetables more than the permissible limit has an adverse impact on human health and plants.

2.3.2 Effect of Contamination on Food Cycle

The main adverse impact of soil contamination is food safety, which can not only affect the nervous system but also induce kidney, liver and bone damage, says a report published by Food and Agricultural Organization (UN Report May 2018). "Soil pollution affects the food we eat, the water we drink, the air we breathe, and the health of our ecosystem," said Maria Helena Semedo, FAO Deputy Director-General. Heavy metals mostly enter the food chain through absorption by plant roots (Brevik .et .al 2013) It goes on add to, for human, presence of Cadmium, which is one of the toxic elements for humans as it can “penetrate during pregnancy, damaging membranes and DNA and disrupting the endocrine system, and can induce kidney, Liver and bone damage” (Burgess .et .al 2013). Now comes to Lead, report says that the earlier researches have shown that lead affects several organs, causing a biochemical imbalance in the liver, kidney, spleen, and lungs causing neurotoxicity, mainly in infants and children (Jordao .et .al 2006). Rather than consuming food the grown in polluted soil, the ways in which people can come in contact with contaminated soil are ingestion, dermal exposure, from using spaces such as parks and gardens or by inhaling soil contaminants that have been vaporized.

2.2.3 Possible Measures

There are some selected measures for the remediations of the contaminated soil are In situ remediation measures, Harsh Soil use restrictive measures and harsh Soil destructive measures. The in situ remediation measures divided into two parts are Stabilization and Decontamination. Gentle remediation techniques can also be uses, It is done by the process when the equilibrium between soluble and insoluble fractions may be either shifted towards more insoluble pr toward more soluble heavy metals.

2.4 UPGRADATION OF STP THROUGH POWER GENERATION TECHNIQUE

2.4.1 Power Generation in STP plants by using turbines

As urbanization is increasing, the pollution level in the river is also being increased. To control t the pollution in Rivers, The numbers of STP plants constructed and still, new STP plant construction is being executed these days. Now, the issues are that these plants require a continuous power supply for their operation 24 hours and seven days, The continuous power demand increases the overall operation and maintenance (O&M) cost. To maintain the O&M cost of STP, The technique of power generation in STP is being suggested. This study is being done on an STP plant at Kanpur having capacity 210 MLD on UASB (Up-flow Anaerobic Sludge Blanket Reactor) technology. After the proper study, It is found that the outlet channel has a length of 250 meters, width 4.1 meters, and depth 1.2 meters, daily discharge of nearly 160 MLD or 1.85m3/sec, drop 2.5 meters (In between channel) and velocity is nearly 2.2m/sec. On looking to the drop and horizontal flow velocity, It is suggested to place the Kaplan turbine and River turbine at the outlet effluent channel to generate power.

2.4.2 Power Generation in STP Plants by using Solar Panels.

The concept of solar energy is well known in today's world, solar energy can be utilized in many ways like a solar water heater, solar stove and power generation by using solar panels. In a developing country like India, power generation through the solar panel is useful technology, especially in a rural area. As, we know that, India mainly depends upon thermal technology for power generation and power generation from thermal energy not only cause pollution in the air as well as produce ash as a waste product, By using solar technology in power generation it can reduce dependency on thermal power. Solar technology is being used everywhere like houses, Schools, Hospitals, Offices, running tube well. Now, solar technology is being prepared to use in the STP plant.

For the study of power generation by solar technology the same 220 MLD STP plant of Kanpur Uttar Pradesh, details of the plant are mentioned earlier. After a proper study being conducted and total loads were calculated. According to the calculation of total loads, they require a capacity of solar power can be calculated, for example, the total load in the STP plant is 322 KW (Kilo Watt), On the basis of the load 375 KW solar power plant setup requirements for the STP plant.

2.5 CONCLUDING REMARKS

In this chapter of the Literature review, three objectives as mentioned in 1.3.2 get discussed in detail. In the first objective of Ganga River Health Assessment, it covers the river pollution worldwide and in India, the impact of river pollution on the environment and human health, Measures taken to clean the river in the entire world and measures taken at national level and the challenges being faced by the authorities to clean the river. In the second objective of the report covers the land contamination issue in soil, the effect of land contamination on human food cycle and crops grown on such type of land and at remediation for the contaminated soil. At last objectives tells about techniques to generate power in the STP plant. There are two suggestions given for power generation, first is by placing Kaplan and water current turbine at outlet channel of STP plant and second is the design of solar plant on the basis of total plant loads capacity.

3.1 GENERAL

For the assessment of the Ganga River, three important cities were selected for the research work. The cities are Haridwar, Kanpur, and Prayagraj, Kanpur is known for the tanning industry as well as maximum discharge contribution from industries into the Ganga River. Haridwar and Prayagraj are well-known pilgrims fair cities in India, Almost nearly 2.5- 5 lacs people come every year to take a holy dip in pilgrim fair organize in Prayagraj. In events like Kumbh and Maha Kumbh, these figures cross more than 10 lacs, pilgrims, to attend such an event. Haridwar is also known for such events like Kumbh and Maha Kumbh, In Haridwar also attracts lacs of pilgrims every year to take a holy dip in Ganga. Other than pilgrims place both Prayagraj and Haridwar also a urbanize city. In both cities, urbanization is increasing day by day, which in turn increases the discharge in the Ganga River. Different places of the study area as shown in Fig 3.1.

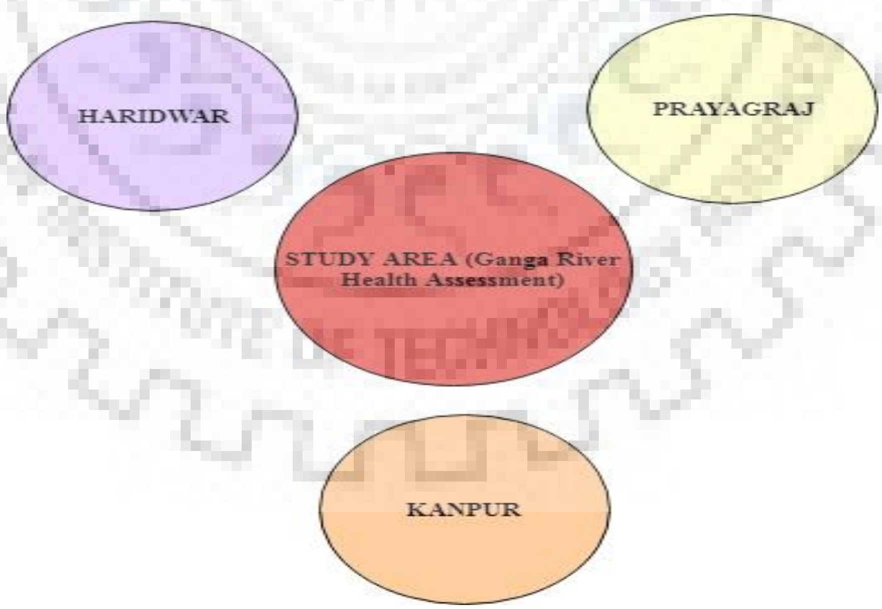


Fig 3.1 Places for Study Ganga River Assessment

3.2 STUDY AREA (River Health Assessment along the Major Cities)

3.2.1 Location and Map

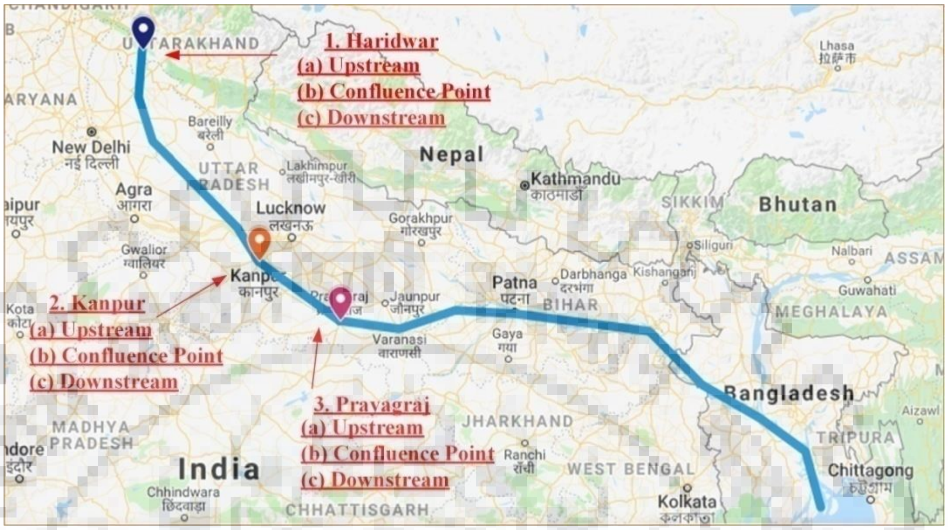


Fig 3.2.1(a) Study Area Point

Haridwar is known as the ancient city of Uttrakhand, Having location of the coordinates 29.945 degrees north 78.163 degrees east, Population of the Haridwar is 2, 28, 832. The average high temp is 36 degrees in the month of May and Average low temp 7 degrees in the month of January, Average maximum precipitation 599 mm (23.6 inches) and Average minimum precipitation 23 mm (0.9 inches). Haridwar is the headquarters and the largest city in the district. It is known as the religious city and also developing beyond religious importance due to the development of industrial estate of State Industrial Development Corporation of Uttrakhand (SIDCUL) and Bharat Heavy Electronics Limited (BHEL).

. The Stretch of the river along Kanpur in Uttar Pradesh has been identified as the most polluted due to the discharge of untreated domestic and industrial wastewater. The tanneries located in the Jajmau of Kanpur city on the south bank of river Ganga are the major source of industrial waste being discharged into the river Ganga (UPJN report). The leather industry is one of the oldest industries in India (UPJN report). Kanpur is an important center for leather processing footwear manufacture and leather goods. The development of tanneries in Kanpur has a history of about 14 decades (Agarwal et, al, 2016). The leather industry which is one of the major foreign exchange earners and an important participant in international commerce is often cited for its environmental pollution (Social Media Report). Kanpur location coordinates 26.449 degrees north 80.331 degrees east, Population of Kanpur is 27, 67,348. Average high temp 40.7 degrees in the month of May and Average low temp 7.9 degrees in the month January, Average maximum precipitation 300.8 mm (11.843 inches) and Average minimum precipitation 5.1 mm (0.201 inches), Average rainy days 13.7 in the month of July.

Allahabad presently known as Prayagraj integral part of east Uttar Pradesh, Having location coordinates of 25 degrees 27 minutes north, 81 degrees 51 minutes east, Population of Allahabad is 11, 17,094. Average high temp 41.6 degrees in the month of May and Average low temp 8.9 degrees in January, Average maximum precipitation 279.0 mm (10.984 inches) and Average minimum precipitation 4.2 mm (0.165 inches). Average rainy days 12.7 in the month of July. Allahabad (Prayagraj) is known as a pilgrim place, where every six years and twelve years festivals like Ardh Kumbha and Maha Kumbha. In this festival around a huge amount of pilgrims came during the Kumbha time to take a holy dip in Ganga. These types of festivals somewhat pollute the River Ganga in an excessive manner.

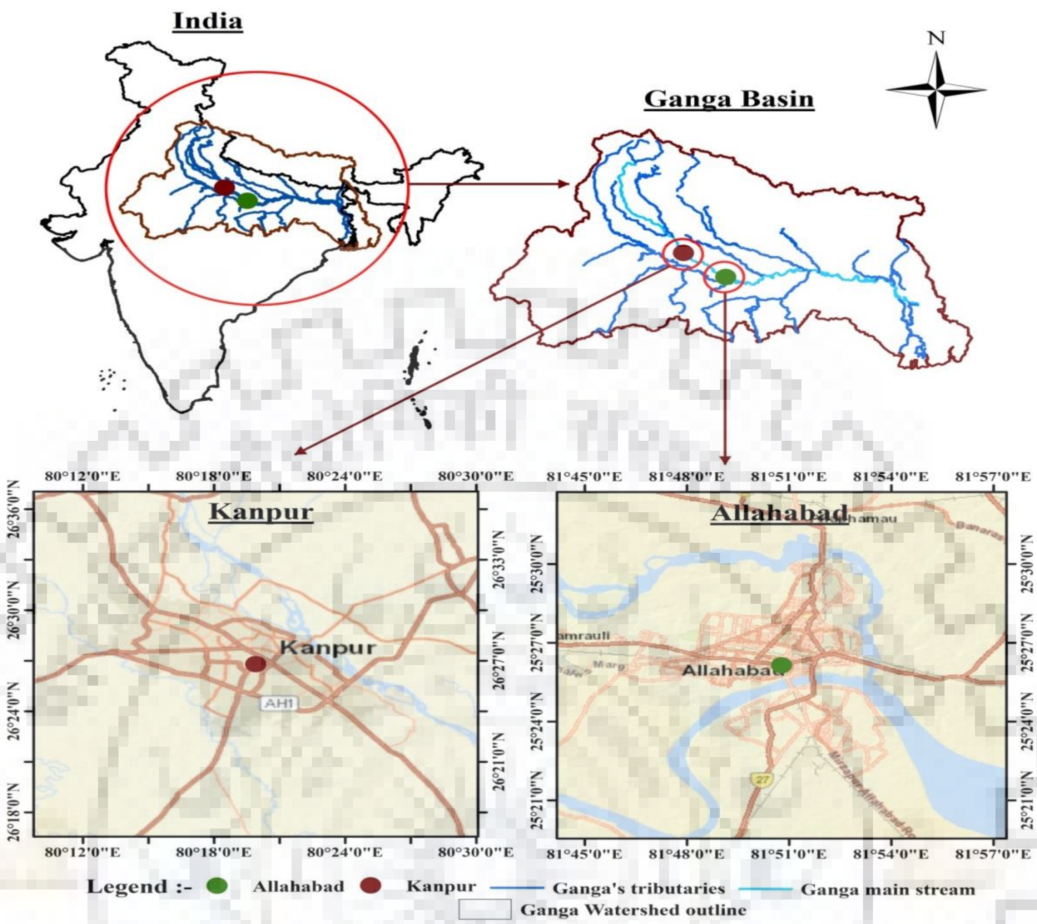


Fig 3.2.1(b) Study Area on Map

3.2.2 Identification of Sampling Location

Location for sampling in three cities Haridwar, Kanpur, and Prayagraj are identified on the basis of the size of the drain and the amount of discharge being released by the drain. In Kanpur, the location is decided on the basis area where maximum industries get established and the drain releases maximum discharge into the River Ganga, for example, I selected Wazidpur to drain in the Jajmau area of Kanpur city. Whereas In Haridwar there is no such drain which consists of Industrial effluent, So I decided to select the residential area, where the maximum amount of sewage wastewater being generated and discharge into the Ganga River, for example, I selected Kankhal area in Haridwar. In Prayagraj also study area selected in the same way as Haridwar, In Prayagraj also there is no any industrial area like Kanpur.

Fig.3.2.2a Sampling Location Prayagraj Pre Mon

Fig.3.2.2b Sampling Location at Prayagraj Mon

Fig.3.2.2c Wazidpur Drain during Post Mon

Fig.3.2.2d Sampling location at Prayagraj Post Mon

3.2.3 Sampling

Major cities were selected along the bank of Ganga River for the sampling, in the cities spots were identified where the quantity of drain discharge into the Ganga River is very high. After the spot got identified in the city, Sampling has to be done. Three samples were collected from the identified spots are Confluence point, 50 m upstream of the confluence and 50 m downstream of the confluence point. There were six pre monsoons samples get collected from six different points from two cities Prayagraj (Fig.3.2.1a) and Kanpur (Fig.3.2.1b), three samples from each city or three different points in each city. During monsoon season, because of the flood situation in Kanpur upstream and downstream samples were not collected. From Kanpur, only confluence point sample was collected whereas from Prayagraj (Fig.3.2.1c) same numbers of samples were collected as during the Pre-monsoon season. In the post-monsoon season, Sample collection was done from Haridwar city (as shown in Fig.3.2.3d) as such as like Kanpur (Fig.3.2.3e) and Prayagraj (as shown in Fig.3.2.3f). Sampling from Haridwar was done to compare the Ganga River parameters difference from Kanpur and Prayagraj. After the analysis of Haridwar samples, It was found that the Ganga River water quality parameters are far much better than the other two cities Kanpur and Prayagraj. At last one more sampling was done, after the Maha Kumbh event in the Prayagraj city, Samples were collected from Kanpur and Prayagraj. After the sampling, the sample was to be preserved in the icebox and test to be started as soon as possible, otherwise, the parameter will be changed.

Fig.3.2.3a Sampling at Prayagraj Pre Monsoon

Fig.3.2.3b Sampling at Kanpur Pre

Fig.3.2.3c Sampling at Prayagraj Monsoon

Fig.3.2.3d Sampling at Haridwar Post Mon

Fig.3.2.3e Sampling at Kanpur Post Mon

Fig.3.2.3f Sampling at Prayagraj Post Mon

Fig.3.2.3g Sampling at Kanpur After Winter

Fig.3.2.3h Sampling at Prayagraj After Winter

3.3 STUDY AREA (Contamination in Agricultural Land)

3.3.1 Location and Map

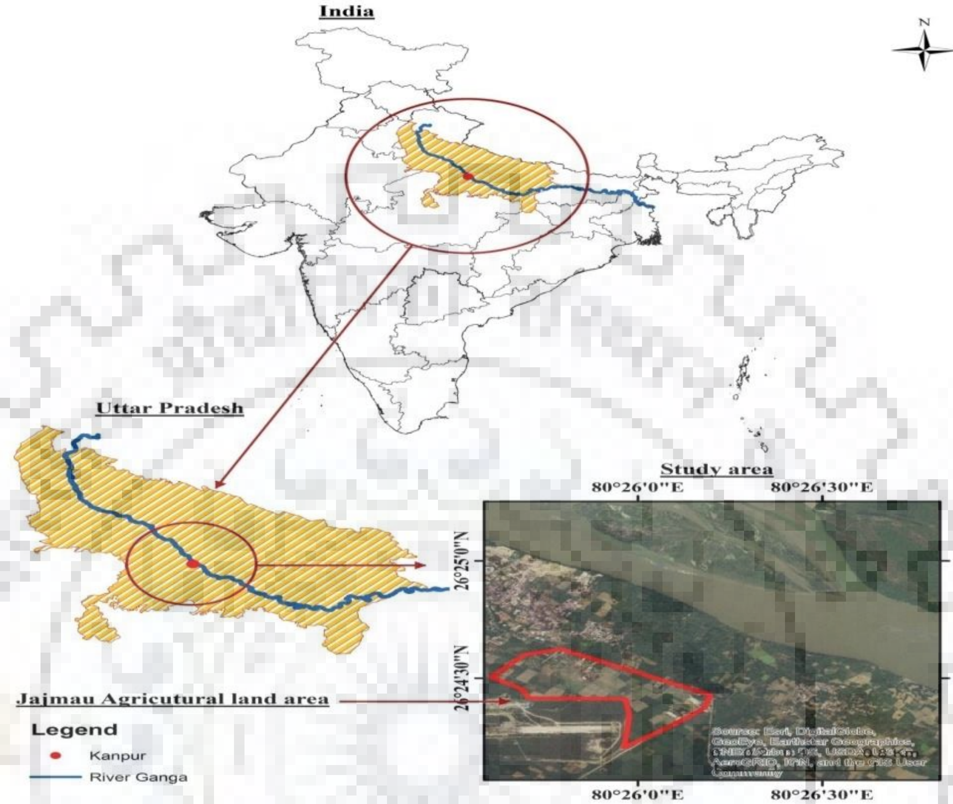


Fig.3.3.1 Study Area Location

Kanpur location coordinates 26.449 degrees north 80.331 degrees east, Population of Kanpur is 27, 67,348. Average high temp 40.7 degrees in the month of May and Average low temp 7.9 degrees in the month January, Average maximum precipitation 300.8 mm (11.843 inches) and Average minimum precipitation 5.1 mm (0.201 inches), Average rainy days 13.7 in the month of July. The Stretch of the river along Kanpur in Uttar Pradesh has been identified as the most polluted due to the discharge of untreated domestic and industrial wastewater. The 75 percent of pollution in the Ganga River mainly from the Kanpur city, Kanpur is mainly known for the tannery. The tanneries located in the Jajmau of Kanpur city on the south bank of river Ganga are the major source of industrial waste being discharged into the river Ganga (UPJN report). Tanning is processed by means of which hides and skins are preserved from decay and converted into an imputrescible substance known as leather (UPJN, Kanpur Report). In India, the use of chromium salts in tanning came into practice in the later part of the 19th. century. There are around 400 tanneries in Kanpur city, The Kanpur's leather and tannery industry contribute to around Rs 6,000 crores worth foreign exchange for the country and also gives direct livelihood to more than one lakh people. The leather industry is one of the oldest industries in India (UPJN report). Kanpur is known to the center for leather processing footwear manufacture and leather goods. The development of tanneries in Kanpur has a history of about 14 decades (Agarwal et, al, 2016). The leather industry which is one of the major foreign exchange earners and an important participant in international commerce is often cited for its environmental pollution (UPJN Report).

3.3.2 Sampling

For sampling agricultural field in the Jajmau area of Kanpur city get selected. The agricultural field of the Jajmau area was contaminated due to irrigation by partially treated tannery effluent. The Jajmau CETP plant is not able to remove the chrome as well as heavy metals from tannery effluent, that's why the Jajmau area agricultural field gets selected for the study of soil contamination. The soil samples are from the same location or nearby previous location, but for different season pre-monsoon (fig 2a), monsoon (fig 2b) and post-monsoon (fig 2c) were collected from agricultural land. Soil samples were collected from the topsoil i.e., 6-17 cm, sampling at such is usually suitable for contamination test study. The samples were collected in a durable plastic bag so that the sample will not get any type of outside contamination.

Fig.3.3.2a Soil Sampling Pre monsoon

Fig.3.3.2b Soil Sample Monsoon

Fig.3.3.2c Soil Sampling Post Monsoon **Fig.3.2.2d** Irrigation Channel in Jajmau

3.4 STUDY AREA (Upgradation of Power System in STP Plant)

3.4.1 Location

This study was conducted at 210 MLD STP plant situated in Bingawan area of Kanpur Uttar Pradesh. Kanpur location coordinates 26.449 degrees north 80.331 degrees east, Population of Kanpur is 27, 67,348. Average high temp 40.7 degrees in the month of May and Average low temp 7.9 degrees in the month January, Average maximum precipitation 300.8 mm (11.843 inches) and Average minimum precipitation 5.1 mm (0.201 inches), Average rainy days 13.7 in the month of July.

Fig.3.4.1 Plan Area of 210 MLD Bingawa STP Plant Kanpur Uttar Pradesh

Orange Line shown in the pictures as the area covered by STP plant, where as pink line shows the outlet of STP plant. This STP Plant is designed for the population of above than 7.5 lacs.

3.4.2 Overview and brief about STP (Sewage Treatment Plant, Field Report)

Sewage Treatment Plant (STP) situated in the Bingawa area of Kanpur city having a design capacity of 210 MLD, which is design for the next 15 years. This plant is based on an up-flow anaerobic sludge blanket reactor (UASBR) followed by the facultative aerated lagoon with a chlorination system. Bingawa STP plant consists of twenty UASB reactors each having a capacity of 10 MLD, forty distribution box on either side of the reactor. Flow from each distribution box is divided into the eight parts before it goes to the feeding box of the reactor. The hydraulic retention time of the UASB reactor is 10-13 hrs for the sewage water. The treated effluent from the UASB reactor conveyed to two facultative types of the aerated lagoon. Each aerated lagoon is divided into two stages of treatments are aeration zone and quiescent zone. In Aeration Zone total 6 numbers of 40 HP of Aerators 3 in each tank have been proposed. In Aeration Zone, aerobic decay of biological load would take place and after that flow will proceed to quiescent zone, which has been designed with an average H.R.T. of 1 day. In quiescent zone settling of settleable solid would take place and BOD / organic load, as well as TSS, is reduced further. The effluent from the quiescent zone will go to the chlorination chamber for the removal of Fecal-coliform / E-Colli. The chlorination tank has been designed in such a way that 30 minutes contact period is assured. After chlorination, the treated sewage is de-chlorinated then discharged into the irrigation canal where it shall be used for irrigation as per requirement and excess effluent remaining after irrigation shall be discharged in the river Pandu. The biogas produced in the reactors is separated with the help of the Gas-Liquid Solids Separators (GLSS) which is placed in the upper part of the reactor. The biogas collected in the gas domes is taken through gas pipes placed along the gas dome bay over the top of the reactor. These gas pipes are connected to a common header pipe going along the reactor and which finally leads through a moisture trap to the biogas holder and dual fuel engine generators as shown in fig.3.2.2d. The fuel in the dual-fuel engine used in the ratios 60:40, which means 60% gas and 40% diesel. The biogas produced is used for generating electricity with the help of dual fuel engines installed at the plant for consumption at the STP, office building, laboratory and campus. A biogas holder for 6 hours production capacity has been provided for biogas storage.

Fig.3.4.2a Screening and Grit Chamber

Fig.3.4.2b UASB reactor (Anaerobic Process)

Fig.3.4.2c Aerated Lagoon (Aerobic Process)

Fig.3.4.2d Dual Fuel Engine at STP plant

Fig.3.4.2e Treated effluent falling into outlet C/h

Fig.3.4.2f Outlet channel of STP Plant

Table 3.4.2 Dimension of effluent Channel

PARAMETERS OF OUTLET C/H	VALUE
Length	250 m
Width	2.15 m

Depth of flow during peak flow	1.2 m
Depth of flow during average flow	0.75 m
Slope in the channel using Manning Eq	1 in 4700

3.5 CONCLUDING MARKS

The study areas of three different objectives are discussed in this part, with the help of maps and photographs tried to show the point location of each study. Data collection points for the three different studies are shown with the help of maps and photographs. The season wise sampling of Ganga River at different cities as shown with the help of photographs, Similarly for the other objectives season wise sampling photographs of the study location were also shown. Procedures for the data collection from the study areas were also discussed in the chapter. In the sampling procedure of Ganga River, collection of sample start from the confluence point of the drain and the river than 50 meters distance upstream side of the confluence point and same distance for the downstream side. The same procedure followed in every season wise sample collection. In the land contamination study, soil sample directly get collected from the field in each every season

CHAPTER 4: GANGA RIVER HEALTH ASSESMENT OF ALONG MAJOR CITIES

4.1 GENERAL

Due to unique geographical, historical, Social, Cultural and economic importance, River Ganga was declared a national and important river. River Ganga" consists of the entire of six head-streams" in the state of Uttrakhand. Due to urbanization in the cities located along the stretch of the Ganga River causes degradation in water quality parameter of the river. It has been facing various types of serious threats like a discharge of excess quantities of sewerage and industrial effluents. "The Stretch of the river along Kanpur in Uttar Pradesh has been identified as the most polluted due to the discharge of untreated domestic and industrial wastewater. The tanneries located in Kanpur city on the south bank of river Ganga contribute reason of 70 percent pollution in the Ganga River. The water quality parameters are divided into three categories; these are Physical, Chemical and Biological parameters. According to the values of the parameter the level of pollution is defined, In the physical parameter tells about the Turbidity of the water, Acidity of the water, Total Hardness as $CaCO_3$, Alkalinity and pH. In chemical parameter also divided into two categories non heavy metals and heavy metals, non metals are nitrate, nitrite, chloride, fluoride, Ammonium etc, and heavy metals are Arsenic, Calcium, Magnesium, Manganese, Iron, Cadmium, Lead, Selenium, Chromium etc,. The biological parameters are Chemical oxygen demand (COD), Dissolved Oxygen (DO) and Biochemical oxygen demand (BOD) standard 3days at 27 degree centigrade.

Turbidity of defined as the point at which light cease to seen, It generally defined as by the light penetration into the water. pH of the water defined as the nature whether it is acidic, basic and neutral. In biological parameter, BOD of water is defined as amount oxygen require by microorganisms to decompose, where as COD is defined amount of oxygen require chemically. Other than that, there is total coli form test, In total coli form test the water is passed through the sterile membrane after that the total numbers coli form on the membrane can be counted manually. Others test for water quality parameter are MPN (Most Probable Number) test, In MPN test different dilution solution are prepared like 1 ml, 10 ml, 100 ml concentration on the basis of the MPN table, the value MPN can be find out. The various test of water quality parameters followed the standard method as given by American water works association and water environment federation.

4.2 METHODOLOGY

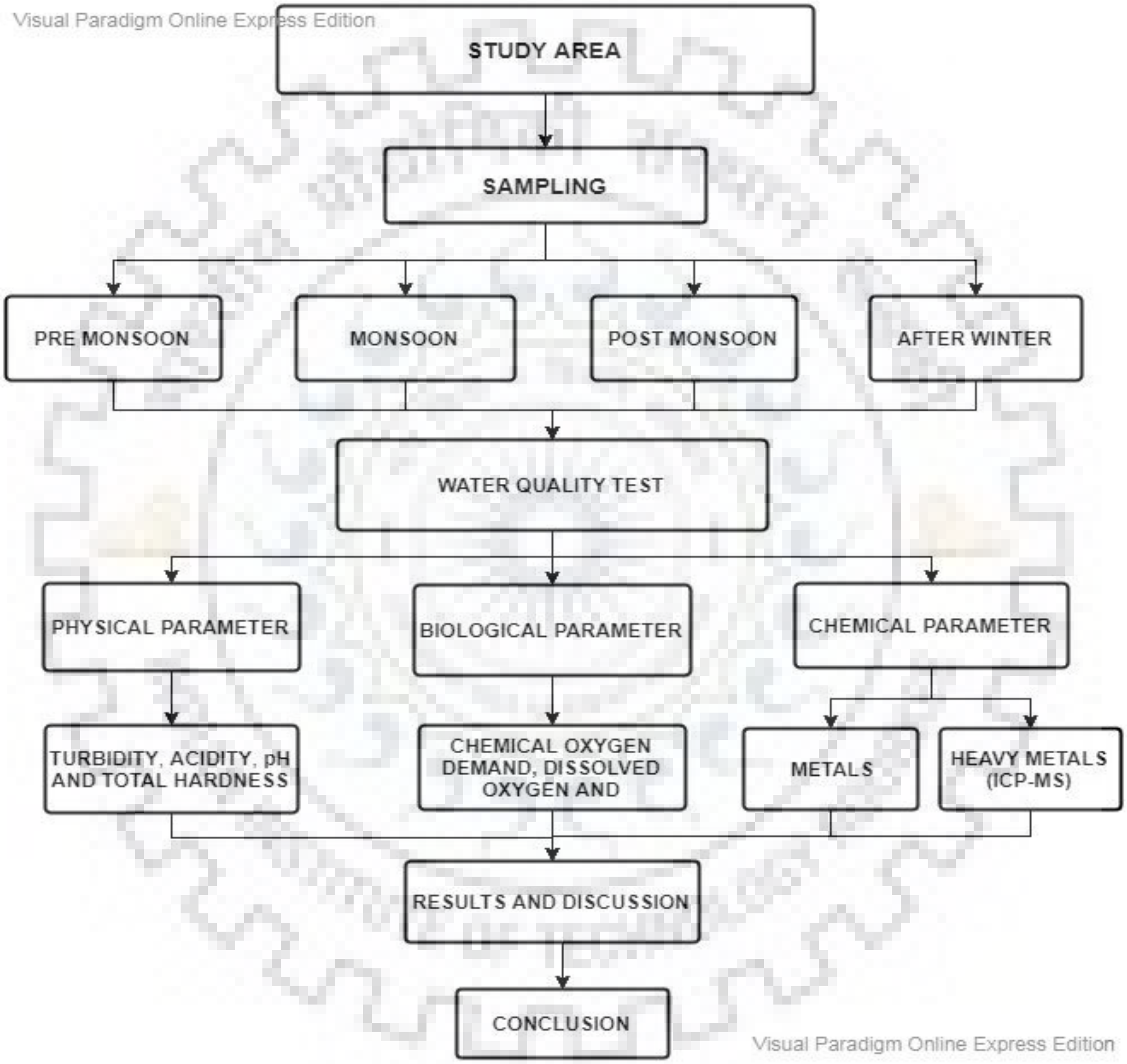
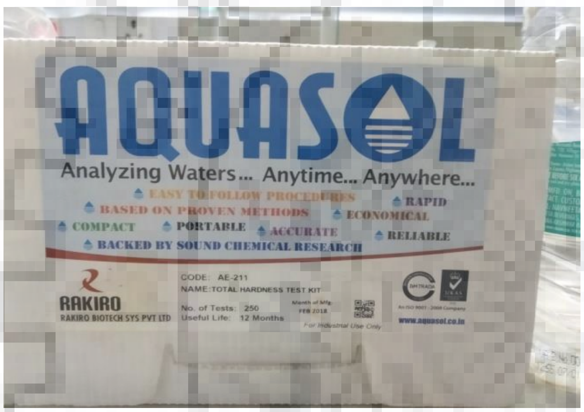


Fig.4.2a Flow chart showing methodology

4.2.1. WATER QUALITY TEST

4.2.1.1 Physical Parameter Test

The physical parameters like Turbidity, Acidity, pH and Total hardness were being tested. The turbidity is being measured by the turbid meter, before measuring the turbidity of the sample in the turbid meter need to adjust the zero of the turbid meter. Afterwards putting the sample in the turbid meter direct reading of turbidity in NTU is shown on the screen. The other physical parameters were measured by using the test kit provided in the lab as shown in figure 4.2.1.1a and b. In each test kit the procedure for measuring the parameters were written, follow the procedure as written in kit then according to the formula as mention in the test kit by using calculate the value of the parameter.



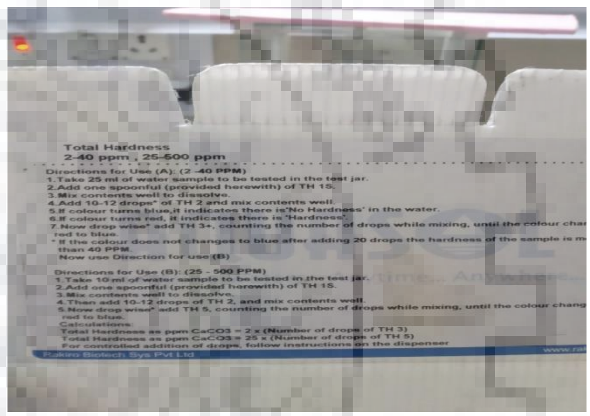


Fig.4.2.1.1a Test kit for measuring Total Hardness **Fig.4.2.1.1b** Procedure for measuring TH

4.2.1.1 Chemical Parameter Test

Chemical Parameter like Nitrate, Nitrite, Fluoride, Chloride and Ammonium were tested by using test kit provided in the WRDM Groundwater Lab, same as mentioned above follow the procedure as given in the kit to get value of each different chemical parameter. The other elements are the heavy metals, the heavy metals test are not possible to test in the lab. The heavy metals test of the samples was done at ICP-MS lab at Instrumentation Center of IIT Roorkee. The procedures for measuring heavy metals were written below.

4.2.1.1Biological Parameter Test

In biological parameters test, firstly perform the test for Chemical oxygen demand (COD), in COD test prepare the solution which consist of 1.5 ml $K_2Cr_2O_7$,2.5ml Sample and 3.5 ml of concentrated H_2SO_4.After the solution is being prepared it get put in to the digester for 120 minutes at 90 degree centigrade. On 120 minutes completed allow the glass tube to get cool. After, we put the solution in the glass tube. Now we put these glass tube inside the COD measuring equipment, from we directly get reading from photometer. After that we measure the dissolved oxygen (DO) from the electronics portable meter, with help for DO the BOD for 3 days 20 degree will be able to calculate by the formula.

((DOI-DOF)sample - (DOI-DOF)blank)/Amount of Sample)*300.

Various methods are being used in the lab for measurement of water quality parameters like physical, chemical and Biological parameters (Tewari et. al. 2012). The permissible limits of these parameters must be followed as per IS 10500. The laboratory test was carried out for the determination of total suspended solids (TSS), Hardness, Turbidity, Dissolved Oxygen ammonia, nitrite, nitrate, Chloride, Fluoride, pH, chemical oxygen demand (COD) biochemical oxygen demand (BOD3day/20 degree) etc are to be performed in Groundwater lab of WRDM department.

The test like pH, Total Harness, Acidity, Ammonium, Nitrate and Nitrite were performed by water testing kit at the Ground water Lab of WRDM , test kit consists of reagents like .02N Sulphuric acid, EDTA. EBT (Eriochrome Black Tea), Silver Nitrate, Potassium Chromate etc. For the measurement COD (Singh et. al. 2009) . I the solution with help of sample and chemical reagents like H_2SO_4, $K_2Cr_2O_7$. After, we put the solution in the glass tube. Now we put these glass tube inside the COD measuring equipment, from we directly get reading from photometer.

Test of Physical, Chemical and Biological Parameters had been performed by using spectrophotometer for COD, DO meter for measuring DO and BOD incubator for standard BOD3days/27 degree. The tests of heavy metals were done at Instrumentation center of IIT Roorkee. In the present study of heavy metals like Calcium (Ca), Magnesium (Mg), Chromium (Cr), Iron (Fe), Zinc (Zn), Arsenic (As) etc over three major cities along the banks of Ganga River, namely Kanpur and Allahabad. From the result, it was observed that Calcium (Ca) and Magnesium (Mg) much less than the permissible limit at every place. Hence Ca and Mg were not mentioned in the report. The traces of Zinc (Zn) at all places were much more than Lead (Pb), Copper (Cu), Cadmium (Cd) and Manganese (Mn), But within the permissible limit. The traces of Chromium (Cr), Iron (Fe), Selenium (Se) and Arsenic (As) were much more than the permissible limit.

4.2.2 Detection of Heavy Metals

4.2.2.1 Preparation of Sample for heavy metal Test

In the test of heavy metals, first, prepare the solution of 50ml with the sample by using reagents like HNO3 and H2O2. Then placed it on the heater to vaporize the extra water heat up to a 10ml solution remains. When the heating process complete allow the solution to cool at room temperature, now pass it through the filter. At last by adding the distilled water again make the solution to 50ml or 100ml. After the sample got prepare metal detection test will be performed.

4.2.2.2 Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

I. About ICP-MS

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was introduced in 1983 for many types of laboratories (Batsala.et. al 2012). ICP-MS is an analytical technique for the detection of heavy metals, it can detect up to parts per trillion (Thomas et. al. 2003). The application of ICP-MS for the detection of metals in different fields including Soil Science, Food Science, Metallurgy, Drinking water, Wastewater etc (Montaser .et. al 1998).

Following important points regarding argon ICP plasma are:

- Argon an excellent ion source having a temperature 6000-10000 degrees Kelvin.
- The ions formed by the ICP discharge are typically positive discharge ions rather than negative ions that's why negative ions are difficult to determine via ICP-MS.
- The amount of sample and sample introduction technique is important for variation of detection capabilities.
- Detection capabilities will vary with the sample matrix, which may affect the degree of ionization that will occur in plasma or allow the formation of species that may interfere with analyte determination.

II. Principle of ICP-MS

The technology couples use of an ICP with MS for detection of heavy metals by the generation of ions (Taylor .et. al 2001). The ICP involved in the generation of high-temperature plasma at

10,000 degrees Celsius, through which the sample is passed. The elements in the sample at such high temperature get ionized and directed further into the MS. The MS then sorts the ions according to their charge ratio followed by directing them to an electron multiplier tube detector. This detector then identifies and quantifies each ion.

III. The process of performing Heavy Metal Detection

i. Sample introduction generating an aerosol of the liquid (or solid) sample.

ii. Plasma source ionizing the aerosol.

iii. Sampling interface extracting ions from ICP.

iv. Ion optics and mass spectrometer focusing and separating ions.

v. Ion detector converting ions into an electronic signal processed by the data handling system.

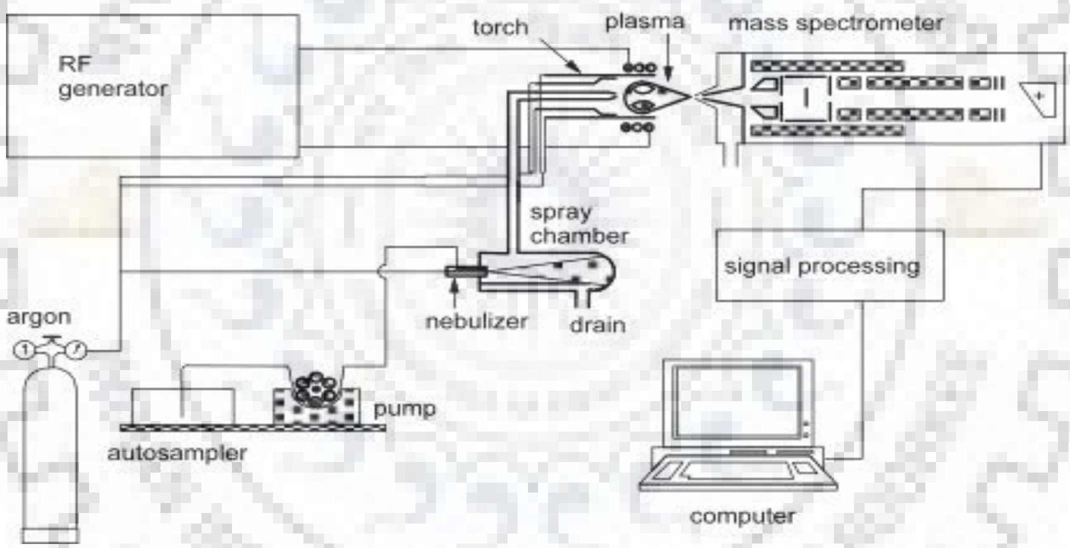


Fig 4.2.2.2 Description of ICPMS process**,** source**:** ***(Loos-Vollebregt*** et. al . 2001)

4.3 RESULTS AND DISCUSSION

4.3.1 Biological Parameter

Table 4.3.1 (a) Kanpur Pre monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point
Dissolved Oxygen (DO)	8.5 mg/lit	3.78 mg/lit	6.5
Chemical Oxygen Demand(COD)	65.67 mg/lit	651.63 mg/lit	72.13 mg/lt
Biochemical Oxygen Demand (BOD3 days/27 degree)	36.78 mg/lit	345.37 mg/lit	34.12 mg/lit

Table 4.3.1 (b) Prayagraj Pre Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point
Dissolved Oxygen (DO)	8.88 mg/lit	5.11 mg/lit	7.83 mg/lit
Chemical Oxygen Demand(COD)	24.45 mg/lit	65.34 mg/lit	35.67 mg/lt
Biochemical Oxygen Demand (BOD3 days/27 degree)	11.74 mg/lit	24.09 mg/lit	16.12 mg/lit

Table 4.3.1 (c) Kanpur Monson

Parameter	Upstream Point	Confluence Point	Downstream Point
Dissolved Oxygen (DO)	-	6.14 mg/lit	-
Chemical Oxygen Demand(COD)	-	86.16 mg/lit	-
Biochemical Oxygen Demand (BOD3 days/27 degree)	-	20.4 mg/lit	-

NOTE: Due to flood condition in Kanpur sample collection at upstream and downstream not done.

Table 4.3.1 (d) Prayagraj Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point
Dissolved Oxygen (DO)	7.03 mg/lit	6.45 mg/lit	6.37 mg/lit
Chemical Oxygen Demand(COD)	3 mg/lit	60 mg/lit	55.13 mg/lit
Biochemical Oxygen Demand (BOD3 days/27 degree)	1.2 mg/lit	28.7 mg/lit	6.36 mg/lit

Table 4.3.1 (e) Haridwar Post Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point
Dissolved Oxygen (DO)	7.52 mg/lit	6.02 mg/lit	7.41 mg/lit
Chemical Oxygen Demand(COD)	31.54 mg/lit	47.61 mg/lit	25.59 mg/lit
Biochemical Oxygen Demand (BOD3 days/27 degree)	3 mg/lit	52.5 mg/lit	5.56 mg/lit

Table 4.3.1(f) Kanpur Post Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point
Dissolved Oxygen (DO)	6.81 mg/lit	5.23 mg/lit	6.21 mg/lit
Chemical Oxygen Demand(COD)	51.56 mg/lit	531.76 mg/lit	27.76 mg/lit
Biochemical Oxygen Demand (BOD3 days/27 degree)	26.55 mg/lit	201.8 mg/lit	14.22 mg/lit

Table 4.3.1 (g) Prayagraj Post Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point
Dissolved Oxygen (DO)	6.81 mg/lit	5.23 mg/lit	6.21 mg/lit
Chemical Oxygen Demand(COD)	51.56 mg/lit	531.76 mg/lit	27.76 mg/lit
Biochemical Oxygen Demand	26.55 mg/lit	201.8 mg/lit	14.22 mg/lit

(BOD3 days/27 degree)			

Table 4.3.1 (h) Kanpur after Winter March 2019

Parameter	Upstream Point	Confluence Point	Downstream Point
Dissolved Oxygen (DO)	8.10 mg/lit	8.06 mg/lit	8.24 mg/lit
Chemical Oxygen Demand(COD)	145.15 mg/lit	392.97 mg/lit	49.05 mg/lit
Biochemical Oxygen Demand (BOD3 days/27 degree)	44 .88 mg/lit	140.84	20.67 mg/lit

Table 4.3.1 (i) Prayagraj after winter March 2019

Parameter	Upstream Point	Confluence Point	Downstream Point
Dissolved Oxygen (DO)	7.96 mg/lit	7.11 mg/lit	8.11 mg/lit
Chemical Oxygen Demand(COD)	143.60 mg/lit	195.72 mg/lit	182.05 mg/lit
Biochemical Oxygen Demand (BOD3 days/27 degree)	26.54 mg/lit	88.76 mg/lit	22 mg/lit

4.3.2 Physical Parameter

Table 4.3.2 (a) Kanpur Pre monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limit
Turbidity	23.51 NTU	28.41 NTU	45.91 NTU	10-25NTU
Acidity	30 ppm	10 ppm	20 ppm	
pH	6.6	5.5	6.7	6.5-8.5
Total Hardness as CaCo3	175 ppm	>350 ppm	200 ppm	300 ppm

Table 4.3.2 (b) Prayagraj Pre monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limit
Turbidity	54.11 NTU	347.52 NTU	17.11 NTU	10-25NTU
Acidity	10 ppm	40 ppm	20 ppm	-
pH	7.2	6.8	6.7	6.5-8.5
CaCo3 Hardness	75 ppm	>125 ppm	75 ppm	300 ppm

Table 4.3.2 (c) Kanpur Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limit
Turbidity	-	289.34 NTU	-	10-25NTU
Acidity	-	10 ppm	-	
pH	-	7.4	-	6.5-8.5
Total Hardness as CaCo3	-	175 ppm		300 ppm

Note-Due to flood situation in Kanpur during monsoon season U/S D/S sampling not done

Table 4.3.2 (d) Prayagraj Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limit
Turbidity	212.36 NTU	46.66 NTU	203.37 NTU	10-25NTU
Acidity	10	10 ppm	10	
pH	7.8	6.5	7.5	6.5-8.5
CaCo3 Hardness	125 ppm	125 ppm	100	300 ppm

Table 4.3.2 (e) Haridwar Post Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limit
Turbidity	22.9 NTU	58.6 NTU	28.6 NTU	10-25NTU
Acidity	10	40 ppm	10 ppm	
pH	6.6	6.4	6.6	6.5-8.5
Total Hardness as CaCo3	100 ppm	>200 ppm	150ppm	300 ppm

Table 4.3.2 (f) Kanpur Post Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limit
Turbidity	78.1 NTU	168 NTU	79.1 NTU	10-25NTU
Acidity	10	30 ppm	10	
pH	6.8	6.3	6.6	6.5-8.5
Total Hardness as CaCo3	200 ppm	>300 ppm	175 ppm	300 ppm

Table 4.3.2 (g) Prayagraj Post Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limit
Turbidity	109 NTU	687 NTU	140 NTU	10-25NTU
Acidity	10	50 ppm	30 ppm	
pH	7.1	6.2	6.5	6.5-8.5
Total Hardness as CaCo3	150 ppm	325 ppm	300 ppm	300 ppm

Table 4.3.2 (h) Kanpur after Winter March 2019

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limit
Turbidity	67.8 NTU	135.72 NTU	109.42 NTU	10-25NTU
Acidity	20 ppm	30 ppm	20 ppm	
pH	6.8	6.6	6.8	6.5-8.5
Total Hardness as CaCo3	125 ppm	>150 ppm	125 ppm	300 ppm

Table 4.3.2 (i) Prayagraj after Winter March 2019

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limit
Turbidity	97.8 NTU	545.8 NTU	166 NTU	10-25NTU
Acidity	20 ppm	70 ppm	20 ppm	
pH	7.5	6.6	7.2	6.5-8.5
Total Hardness as CaCo3	100 ppm	325 ppm	125 ppm	300 ppm

4.3.3 Chemical Parameter

Table 4.3.3 (a) Kanpur Pre monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limits
Ammonium	0.5 ppm	4 ppm	0.5 ppm	-
Nitrate	1 ppm	0.5 ppm	1 ppm	-
Nitrite	0.05 ppm	250 ppm	200 ppm	-
Chloride	20 ppm	300 ppm	40 ppm	250 ppm

Fluoride	1 ppm	4 ppm	4 ppm	0.6-1.2ppm

Table 4.3.3 (b) Prayagraj Pre monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limits
Ammonium	0.5 ppm	0.5 ppm	0.5 ppm	-
Nitrate	2.5 ppm	1 ppm	1 ppm	-
Nitrite	200 ppm	200 ppm	200 ppm	-
Chloride	30 ppm	80 ppm	60 ppm	250 ppm
Fluoride	0.2 ppm	0.5 ppm	0.4 ppm	0.6-1.2ppm

Table 4.3.3 (c) Kanpur Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limits
Ammonium	-	0.5	-	-
Nitrate	-	1 ppm	-	-
Nitrite	-	250 ppm	-	-
Chloride	-	130 ppm	-	250 ppm
Fluoride	-	5 ppm	-	0.6-1.2ppm

NOTE: In monsoon season due to flood condition in Kanpur U/S and D/S sampling were not done.

Table 4.3.3 (d) Prayagraj Monsoon

Parameter	Upstream Point	Confluence Point	Downstream Point	Permissible Limits
Ammonium	0.5 ppm	0.5 ppm	0.5 ppm	-
Nitrate	1 ppm	1 ppm	1 ppm	-

Nitrite	150 ppm	150 ppm	150 ppm	-
Chloride	10 ppm	10 ppm	10 ppm	250 ppm
Fluoride	0.5	2 ppm	0.9 ppm	0.6-1.2ppm

Table 4.3.3 (e) Haridwar Post monsoon

Parameter	**Upstream Point**	**Confluence Point**	**Downstream Point**	**Permissible Limits**
Ammonium	0.5 ppm	2 ppm	1ppm	-
Nitrate	0.5 ppm	30 ppm	1 ppm	-
Nitrite	10 ppm	50 ppm	10 ppm	-
Chloride	< 10 ppm	40 ppm	10 ppm	250 ppm
Fluoride	4 mg/lit	5 ppm	4 ppm	0.6-1.2ppm

Table 4.3.3 (f) Kanpur Post monsoon

Parameter	**Upstream Point**	**Confluence Point**	**Downstream Point**	**Permissible Limits**
Ammonium	2 ppm	6 ppm	4 ppm	-
Nitrate	1 ppm	20 ppm	7.5	-
Nitrite	150 ppm	250 ppm	100 ppm	-
Chloride	40 ppm	350 ppm	60 ppm	250 ppm
Fluoride	5 mg/lit	11 ppm	5 ppm	0.6-1.2ppm

Table 4.3.3 (g) Prayagraj Post monsoon

Parameter	**Upstream Point**	**Confluence Point**	**Downstream Point**	**Permissible Limits**

Ammonium	0.5 ppm	4 ppm	4 ppm	-
Nitrate	1 ppm	50 ppm	7.5 ppm	-
Nitrite	100 ppm	150 ppm	100 ppm	-
Chloride	20 ppm	70 ppm	60 ppm	250 ppm
Fluoride	4 mg/lit	8 ppm	6 ppm	0.6-1.2ppm

Table 4.3.3 (h) Kanpur After winter March 2019

Parameter	**Upstream Point**	**Confluence Point**	**Downstream Point**	**Permissible Limits**
Ammonium	2 ppm	4 ppm	4 ppm	-
Nitrate	2.5 ppm	20 ppm	10 ppm	-
Nitrite	150 ppm	150 ppm	150 ppm	-
Chloride	90 ppm	180 ppm	40 ppm	250 ppm
Fluoride	5 ppm	5 ppm	5 ppm	0.6-1.2ppm

Table 4.3.3 (i) Prayagraj After winter March 2019

Parameter	**Upstream Point**	**Confluence Point**	**Downstream Point**	**Permissible Limits**
Ammonium	2 ppm	4 ppm	4 ppm	-
Nitrate	1 ppm	50 ppm	1 ppm	-
Nitrite	150 ppm	200 ppm	150 ppm	-
Chloride	20 ppm	90 ppm	20 ppm	250 ppm
Fluoride	5 ppm	8 ppm	4 ppm	0.6-1.2ppm

4.3.2.1 Heavy Metals

Test Results (Kanpur and Prayagraj Pre monsoon)

From the result, it was observed that Calcium (Ca) and Magnesium (Mg) much less than the permissible limit at every place. Hence Ca and Mg were not mentioned in the above graph. The traces of Zinc (Zn) at all places were much more than Lead (Pb), Copper (Cu), Cadmium (Cd) and Manganese (Mn), But within in permissible limit as shown in table 4.3.2.1. Whereas Pb, Cu, Cd and Mn presence in very small amount. From the analysis, it had been observed that in Kanpur, the traces of Chromium (Cr), Iron (Fe), Selenium (Se) and Arsenic (As) were much more than the permissible limit. The traces of different elements of Kanpur samples are in parts per million (ppm) as shown in figure.4.3.2.1a are such as Cr 0.02-0.98 ppm, Fe 1.9-2.3 ppm, Se 1.8-2.3 ppm, As 3.8-4.2 ppm. In Allahabad as shown in figure 4.3.2.1, the presence of Cr is much less than the Kanpur, but it can be observed from the graph traces of other elements like Fe, Se, and As are very high. Their ranges are such as Cr 0.01-0.04 ppm, Fe 3.6-8.2 ppm, Se 1.5 ppm, As 5-5.5 ppm.

Table.4.3.2.1 Indian Standards 10500 for Drinking Water Limits

Elements	**Abbreviation**	**Permissible Limit (ppm)**
Calcium	Ca	75
Magnesium	Mg	30
Copper	Cu	0.05
Iron	Fe	0.3
Manganese	Mn	0.1
Cadmium	Cd	0.01
Selenium	Se	0.01
Arsenic	As	0.05
Lead	Pb	0.1
Chromium	Cr	0.05
Zinc	Zn	5

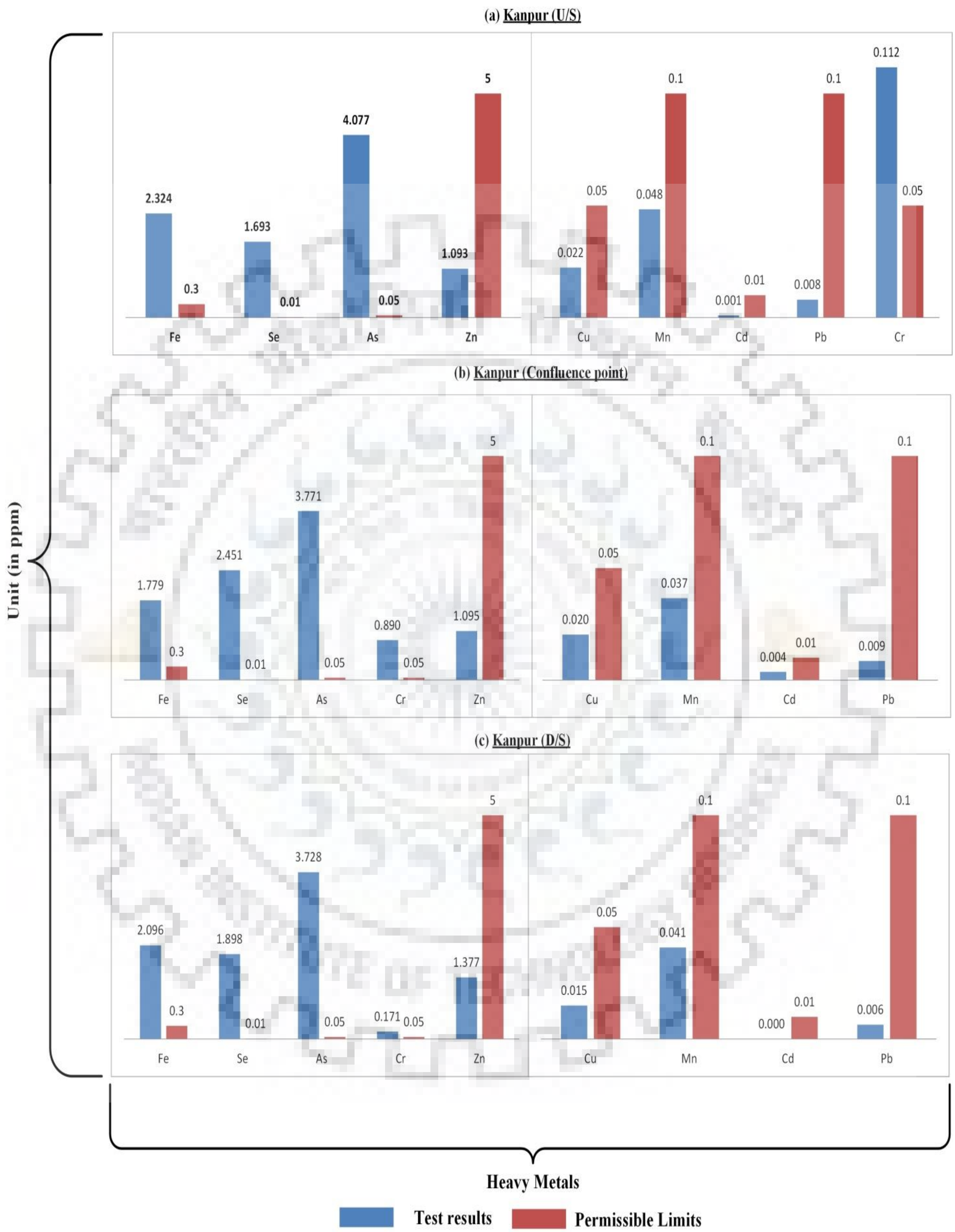


Fig.4.3.2.1a Concentration of heavy metals (Kanpur pre-monsoon) along with permissible

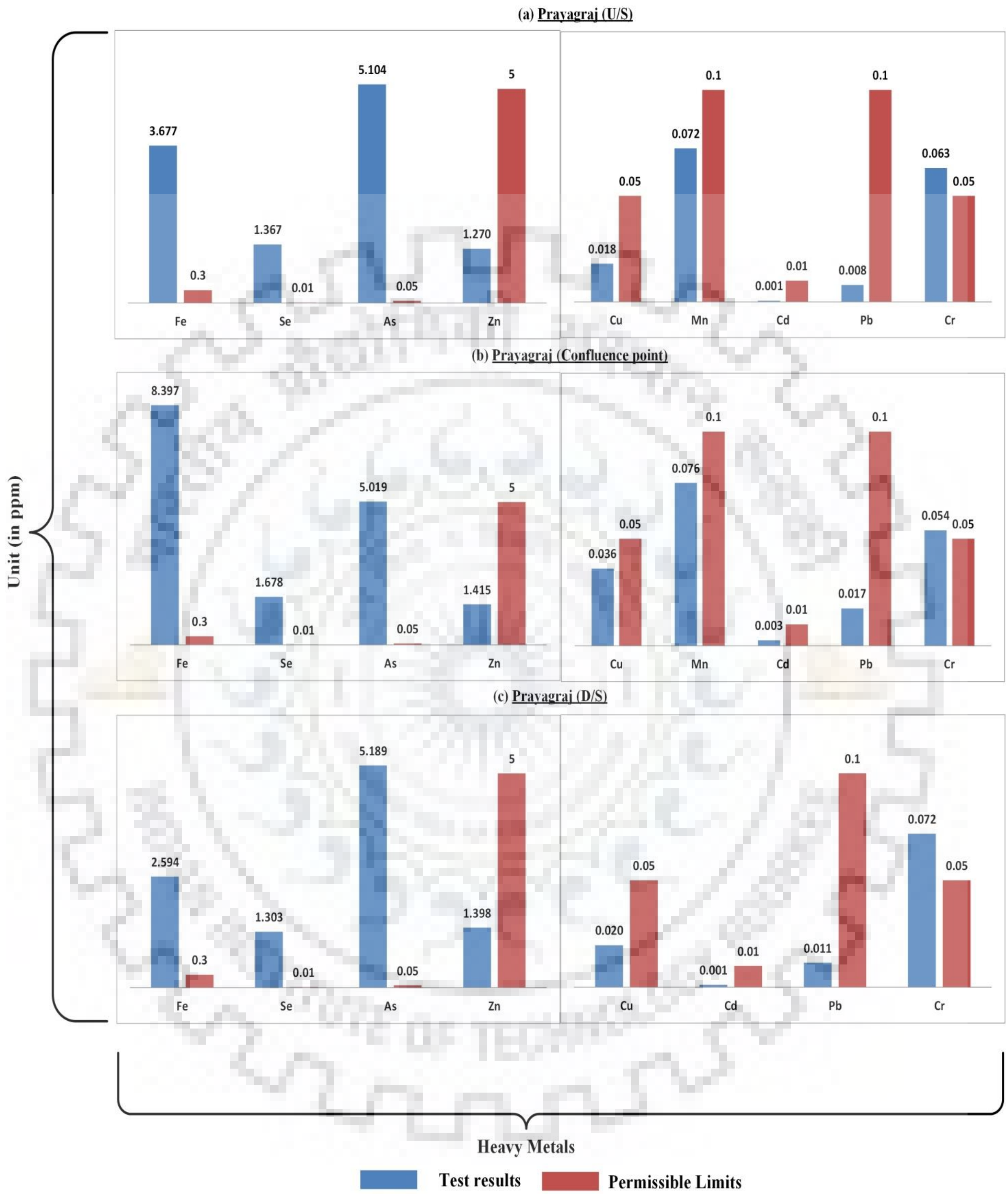


Fig.4.3.2.1b Concentrations of elements (Prayagraj Pre monsoon) along with limits

Test Results (Kanpur and Prayagraj Monsoon)

From the graph of monsoon sample analysis, it can be observed that the traces of different elements in Kanpur as shown in fig.4.3.2.1c such as Cr 0.48 ppm, Fe 3.48ppm, Se 1.8 ppm and As 6.4ppm.In Allahabad, the traces of elements as shown Fig.4.3.2.1d at different points are, at upstream Cr 0.01 ppm, Fe 5.12ppm, Se 1.0ppm, As 8.71ppm. At confluence point Cr 0.1ppm, Fe 0.93ppm, Se 1.16ppm, As 4.52ppm.At downstream point Fe 3.08ppm, Se 0.96ppm and As 6.04ppm. Table 4.3.2.1 above shows the permissible limit of different elements like Fe, Se, As, Cr etc.

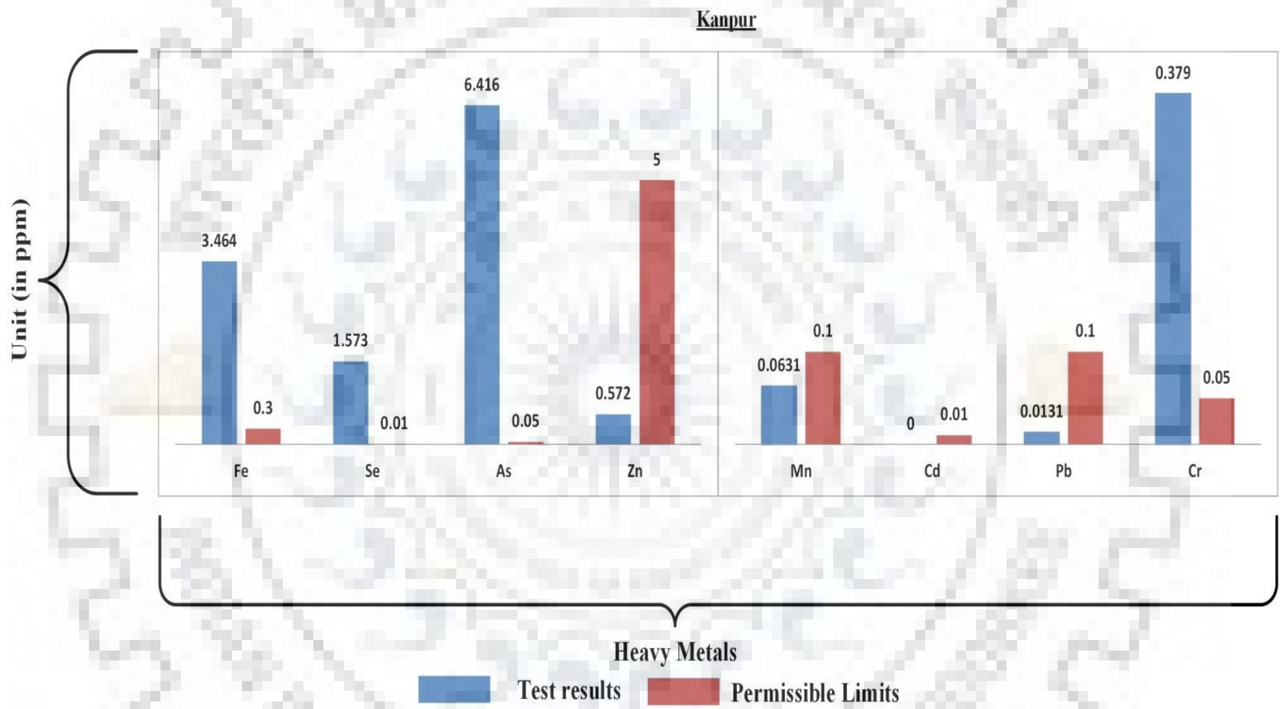


Fig.4.3.2.1c Concentrations of elements (Kanpur Monsoon) along with limits

NOTE: Due to flood condition at Kanpur location Upstream and Downstream sampling not done.

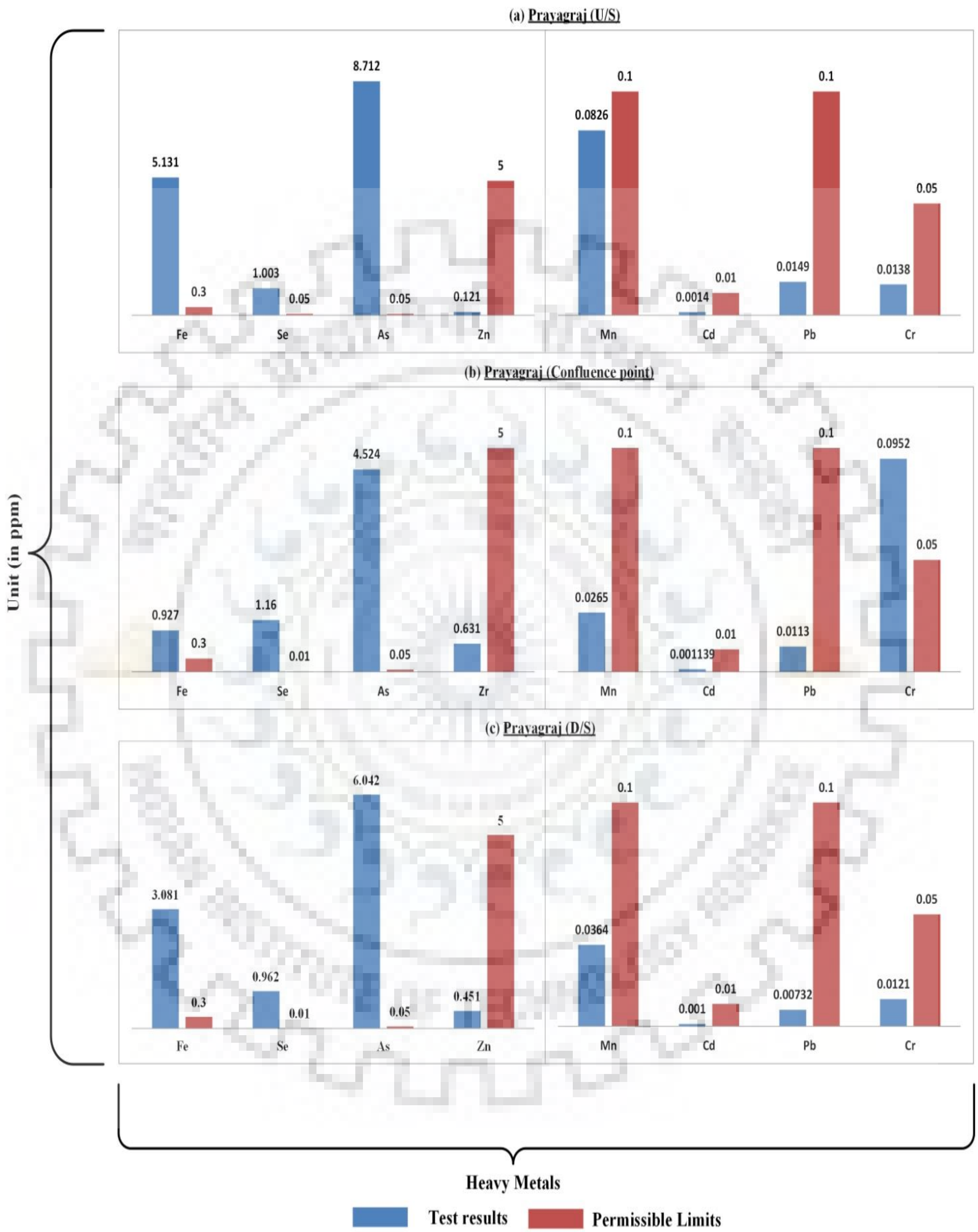


Fig.4.3.2.1d Concentrations of elements (Prayagraj Monsoon) along with limits

Test Results (Haridwar, Kanpur and Prayagraj Post monsoon)

The concentration of some elements like arsenic (As), iron (Fe) and selenium (Se) at Haridwar (as shown in Fig.4.3.2.1e are just exceeded the permissible Limit as shown in IS 10500. As compared to the samples of Kanpur and Prayagraj, the elements concentration is much less. The traces of elements at Haridwar were at upstream Fe 0.831 ppm, As 2.29ppm and Se 0.79 ppm, where as other elements like manganese (Mn), Cadmium (Cd), Lead (Pb), Copper (Cu) and Chromium (Cr) are much least than the permissible limit table 4.3.2.1. Similarly at the other two points also confluence and upstream point, the traces of elements As, Fe and Se are remains more than permissible limit. At confluence As 2.02 ppm, Fe 0.7ppm and Se 0.78ppm and at downstream As 2.24, Fe 0.92ppm and Se 0.83ppm. The remaining elements are less the permissible limits.

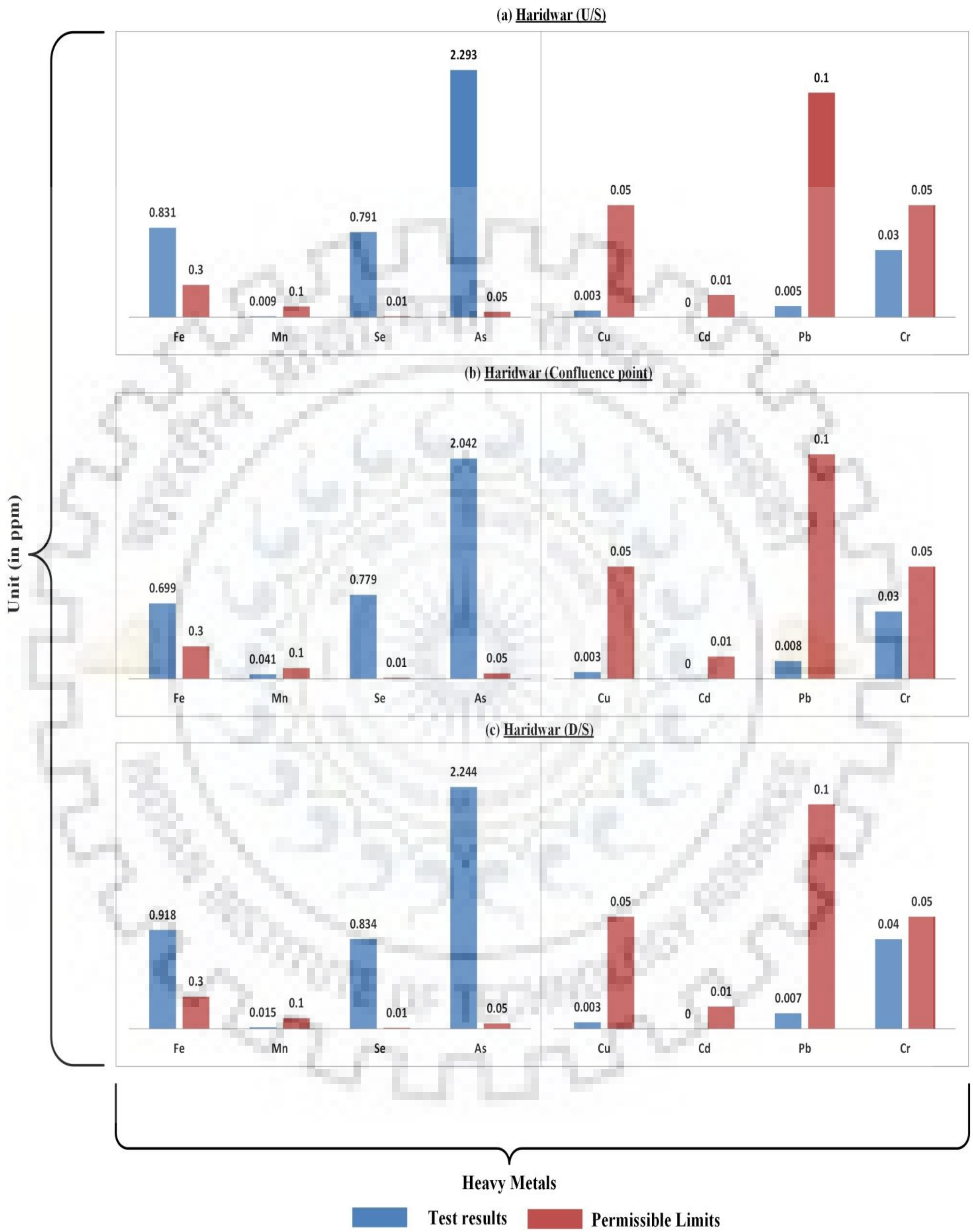


Fig.4.3.2.1e Concentration of elements (Haridwar Post monsoon) along with limits

In Kanpur (as shown in Fig.4.3.2.1 f) the traces of elements are As 3.35ppm, Fe 1.51ppm, Se 0.74ppm and Cr 0.07 ppm at upstream side, As 3.43ppm, Fe 3.02ppm, Se 0.7ppm and Cr 4.85ppm at Confluence point and at downstream point As 3..93ppm, Fe 2.32 ppm, Se 0.77ppm and Cr 0.28ppm.Where as other elements like Mn, Pb, Cd and Cu are within the permissible limits as IS 10500.

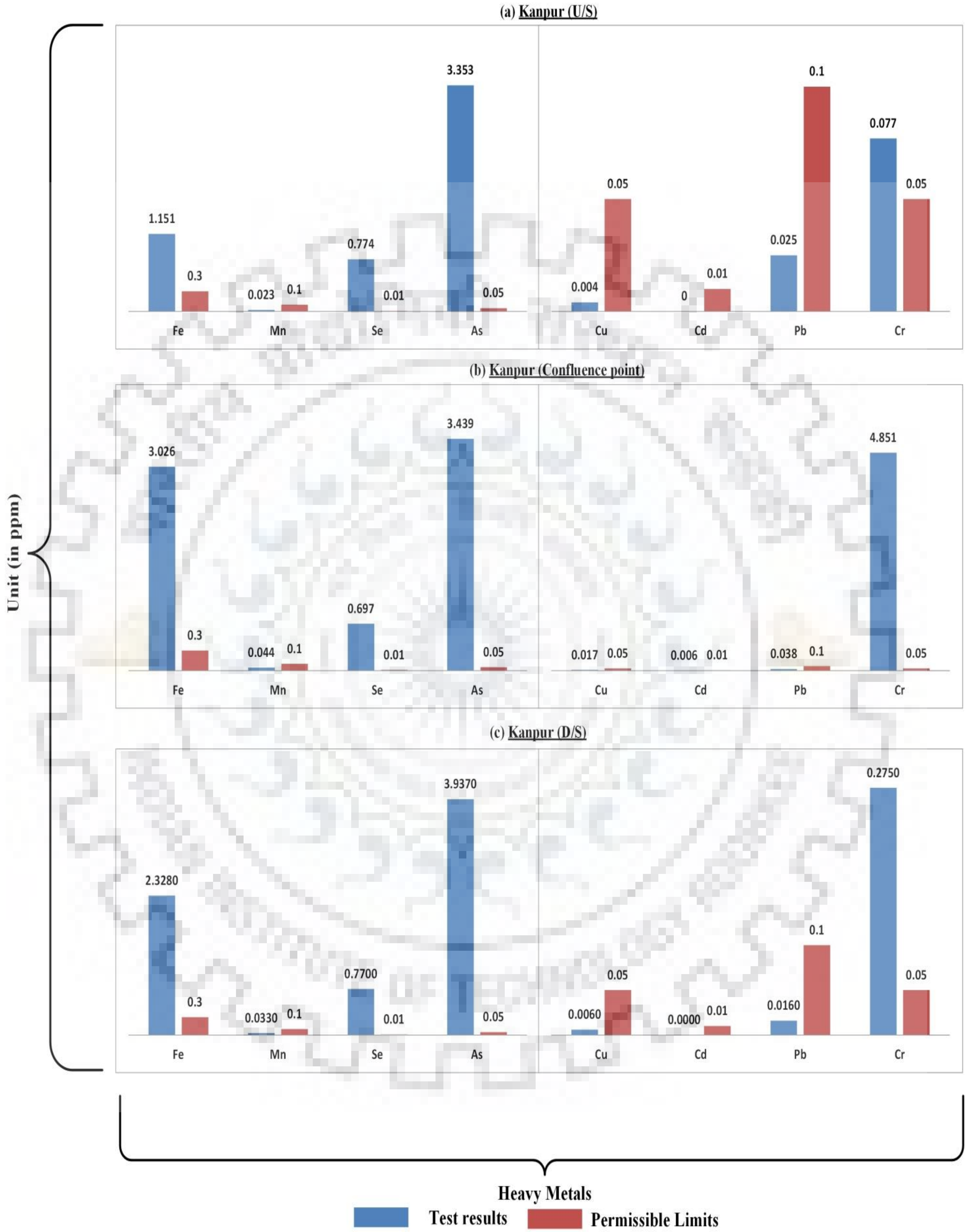


Fig.4.3.2.1f Concentration of elements (Kanpur Post Monsoon) along with the Limits

In Prayagraj(Fig.4.3.2.1 g) the traces of elements like As, Fe and Se are 4.51ppm, 4.62ppm and 0.77ppm at U/S side, 15.07ppm, 12.69ppm and 0.76 ppm at confluence point and 9.72ppm,2.83ppm and 0.76ppm at D/S side. The traces of Chromium at Prayagraj were within in the permissible limit as IS 10500, but at confluence Cr 0.052ppm just exceeded the permissible limit. The remaining elements are within the permissible limits.

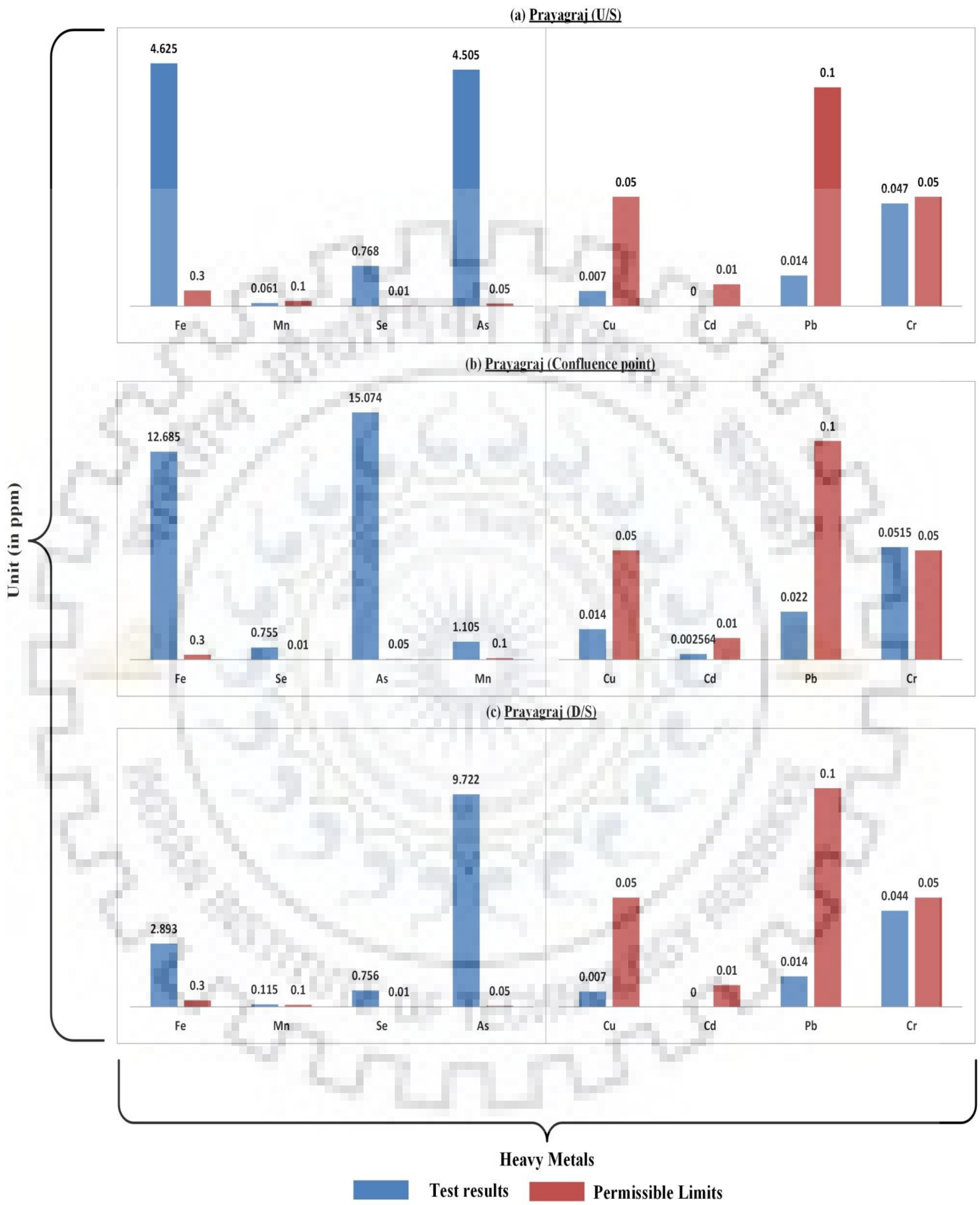


Fig.4.3.2.1g Concentration of elements (Prayagraj Post Monsoon)

Test Results March 2019 (Kanpur and Prayagraj after winter)

From the results, it can be concluded that the traces of chromium in Kanpur get reduced due to tapping of the effluent drains. But the traces of arsenic were found, it may be possible due to soil degradation along the banks of the Ganga River. The traces of elements at Kanpur(Fig.4.3.2.1h) were As 12.09ppm, Fe 0.98ppm, Se 0.75, Cr 0.02ppm, Cu0.005ppm,Pb 0.005ppm, and Mn 0.017ppm are trace at 50 meter upstream side from the confluence point, As 11.8ppm, Fe 0.74ppm, Se 0.77ppm, Cr 0.045ppm, Cu 0.006ppm, Pb 0.007 and Mn 0.017ppm are traces at confluence point, As 10.4ppm, Fe 0.36ppm, Se 0.74ppm,Cr 0.033ppm, Cu 0.008ppm, Pb 0.004ppm and Mn 0.0087 at 50 meter downstream from the confluence point, As 8.41ppm, Fe 0.25ppm, Se 0.71ppm, Cr 0.021ppm, Cu 0.004ppm, Pb 0.003ppm and Mn 0.006ppm. In Prayagraj (4.3.2.1i) sample the trace of elements are As 10.72ppm, Fe 1.15, Se 0.72, Cu 0.005, Pb 0.004ppm and Mn 002ppm at 50 meter upstream side of the confluence point, As 14.33ppm, Fe 1.6ppm, Se 0.69ppm, Cr 0.02ppm, Pb 0.005ppm and Mn 0.049ppm at confluence point, As 10.13ppm, Fe 0.69ppm, Se 0.65ppm, Cr0.013ppm and Mn 0.014ppm at 50 meter downstream from the confluence point.

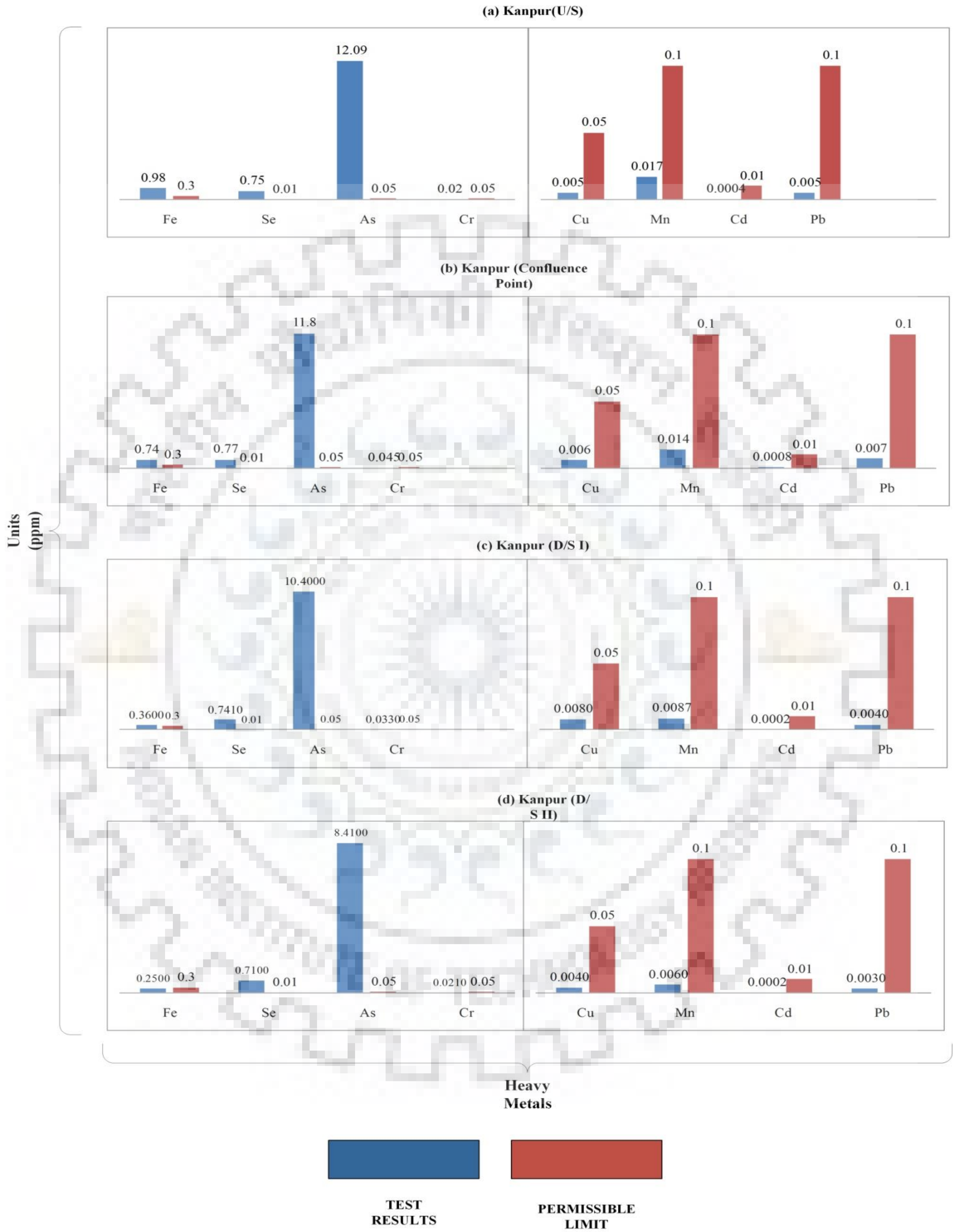


Fig.4.3.2.1h Concentration of elements (Kanpur March 2019 after winter)

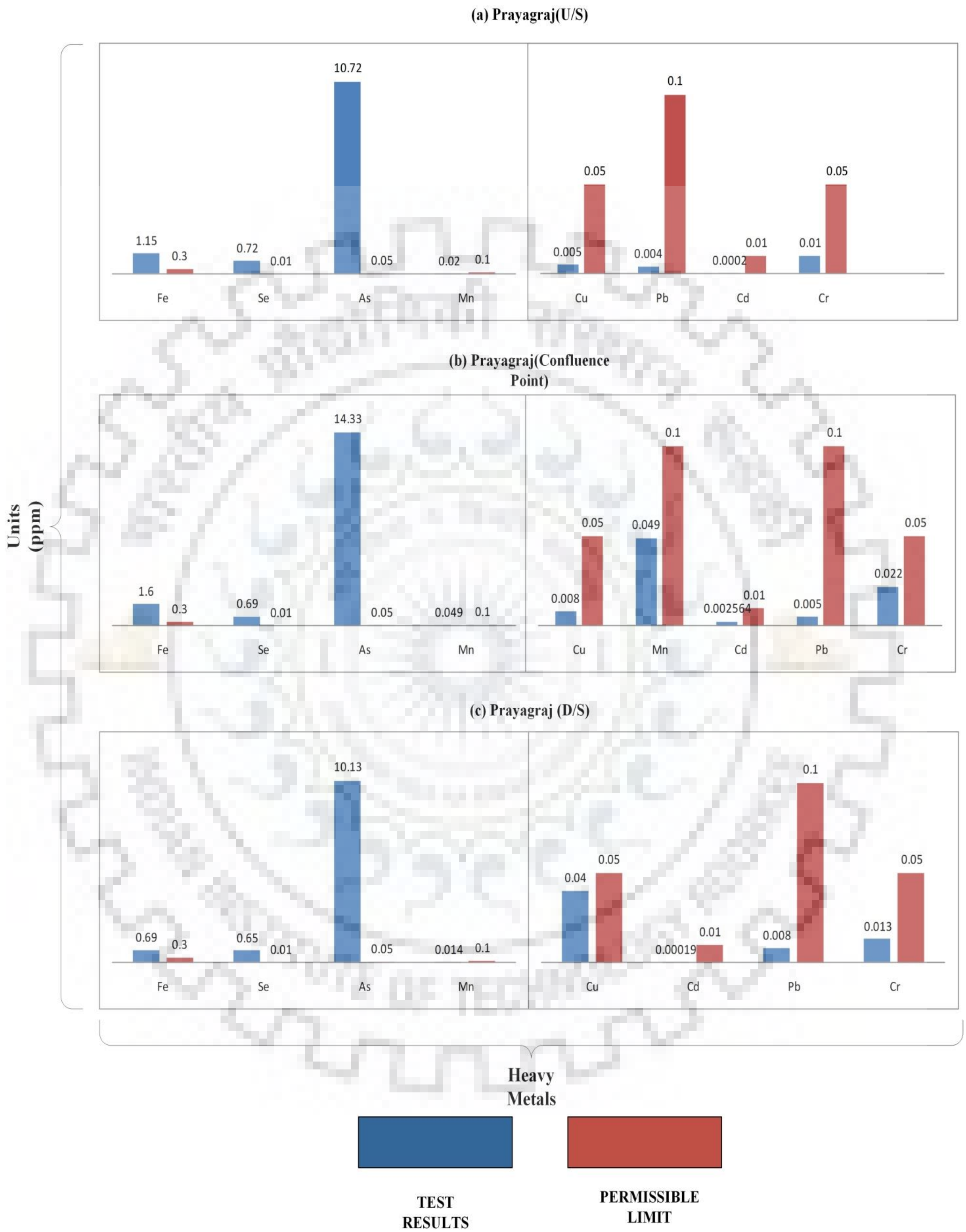


Fig.4.3.2.1i Concentration of elements (Prayagraj March 2019 after Kumbh)

4.4 CONCLUDING REMARKS

Diseases like renal dysfunction, Lung diseases, Kidney and Liver damage, Damage to nerve tissue, Bone disorder, Damage to the central nervous system etc, cause on human life. The presence of heavy metals in soil can reduce crop production, also contaminated the river or lake which in turns destroy underwater ecosystem like the killing of fishes, destroy of aquatic plants etc. We need to identify those industries, which are discharging their effluent directly into the Ganga River and strict action must be taken against them. The proper channel should be constructed to monitor large and small-scale industries, which are discharging their effluent into the Ganga River. A government should conduct awareness program among the public, not to consume water directly for daily and drinking purposes.

5.1 GENERAL

Presence of different types of harmful elements in agricultural soil well known as contamination in soil. These elements have not only an inverse effect on the environment but also get into the human food cycle, which results in various types of health problems. This is often caused by the release of industrial effluent or accidental release of chemicals. In developing countries like India, disposal of industrial effluent with proper treatment is one of the major challenges for the authorities (Gowd et al.2010). Metals such as Zn, Cu, Se, Mg, Mn, As, Pb and Cr are within permissible limit beneficial to vegetables, crops, plants and human life (Sharma et al. 2006). However, the presence of such elements in an excessive amount becomes toxic. The accumulation of heavy elements in crops and vegetables more than the permissible limit has an adverse impact on human health and plants.

5.2 METHODOLOGY

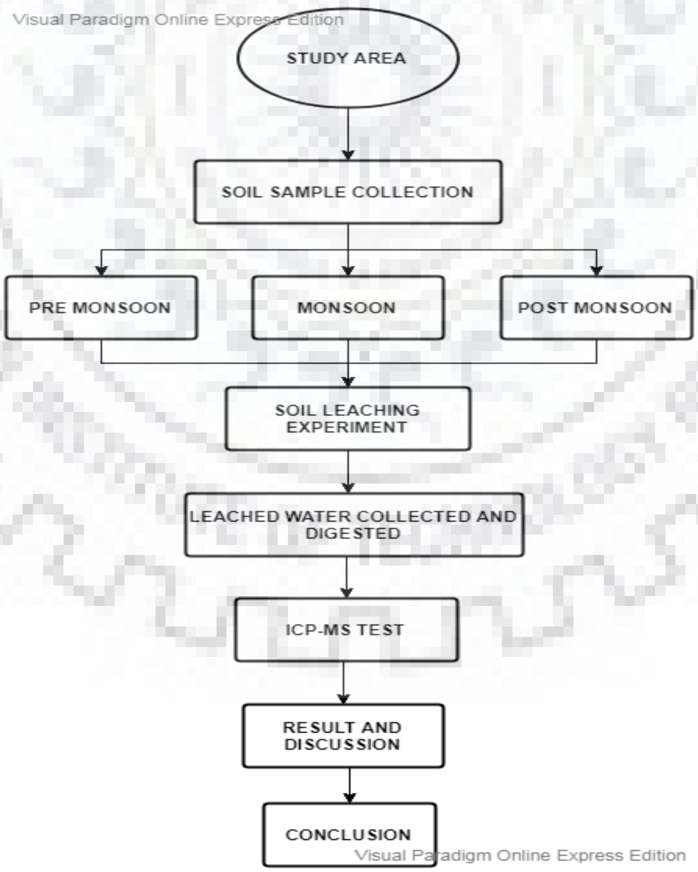


Fig 5.2 Showing the methodology adopted

5.2.1 Leaching Experiment

With the help of experimental setup in the lab as shown in Fig.5.2.1, the soil leaching test was performed. The experimental setup consists of a transparent fiberglass cylinder of the diameter of 10 cm(centimeters), length 63 cm and cast iron stand. In the test soil sample is to be filled in the cylinder up to nearly 35 cm depth. Afterward, tap water is passed through the soil sample by means capillary pipe at a slow flow rate. Leached water is collected through a tap at the bottom of the cylinder, This process is continued for 2-6 days. A flow rate of water is adjusted according to the require condition otherwise waterlogging condition takes place. Now Collected leached water, a further test of heavy metals should be done.

Fig.5.2.1 Soil leaching setup

5.2.2 Leached water Sample Preparation for Heavy Metal Test

In the test of heavy metals, first, prepare the solution of 50ml with the sample by using reagents like HNO3 and H2O2. Then placed it on the heater to vaporize the extra water heat up to a 10ml solution remains. When the heating process complete allow the solution to cool at room temperature, now pass it through the filter. At last by adding the distilled water again make the solution to 50ml or 100ml. After the sample got prepare metal detection test will be performed.

5.4.2 ICP-MS TEST

I. About ICP-MS

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) was introduced in 1983 for many types of laboratories (Batsala.et. al 2012). ICP-MS is an analytical technique for the detection of heavy metals, it can detect up to parts per trillion (Thomas et. al. 2003). The application of ICP-MS for the detection of metals in different fields including Soil Science, Food Science, Metallurgy, Drinking water, Wastewater, etc (Montaser .et. al 1998).

Following important points regarding argon ICP plasma are:

- Argon an excellent ion source having a temperature 6000-10000 degrees Kelvin.
- The ions formed by the ICP discharge are typically positive discharge ions rather than negative ions that's why negative ions are difficult to determine via ICP-MS.
- The amount of sample and sample introduction technique is important for variation of detection capabilities.
- Detection capabilities will vary with the sample matrix, which may affect the degree of ionization that will occur in plasma or allow the formation of species that may interfere with analyte determination

II. Principle of ICP-MS

The technology couples use of an ICP with MS for the detection of heavy metals by the generation of ions (Taylor .et. al 2001). The ICP involved in the generation of high-temperature plasma at 10,000 degrees Celsius, through which the sample is passed. The elements in the sample at such high temperatures get ionized and directed further into the MS. The MS then sorts the ions according to their charge ratio followed by directing them to an electron multiplier tube detector. This detector then identifies and quantifies each ion.

III. Functional Components of ICP-MS

The various components of ICP-MS and its function described as shown in fig.5.4.2a

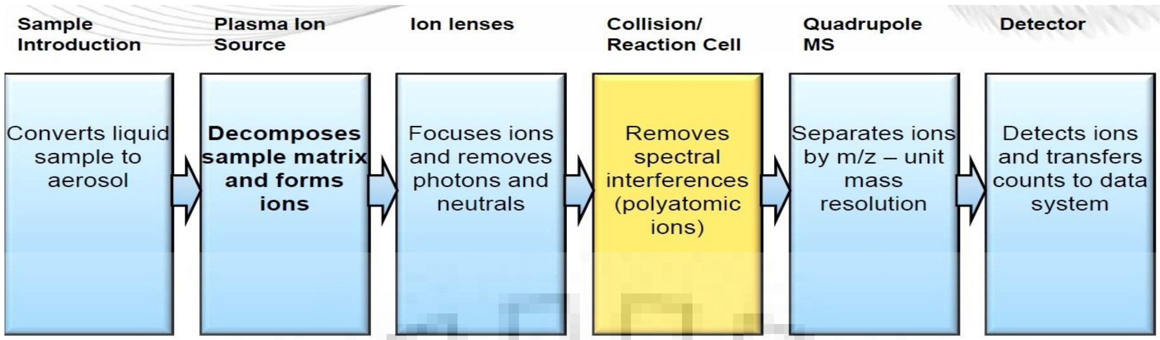


Fig.5.4.2a The Components in ICP-MS

IV. The process of performing Heavy Metal Detection

When the sample got introduce into the ICP-MS instrument following process is involved in the elemental analysis as shown in fig 5.

i. Sample introduction generating an aerosol of the liquid (or solid) sample.

ii. Plasma source ionizing the aerosol.

iii. Sampling interface extracting ions from ICP.

iv. Ion optics and mass spectrometer focusing and separating ions.

v. Ion detector converting ions into an electronic signal processed by the data handling system.

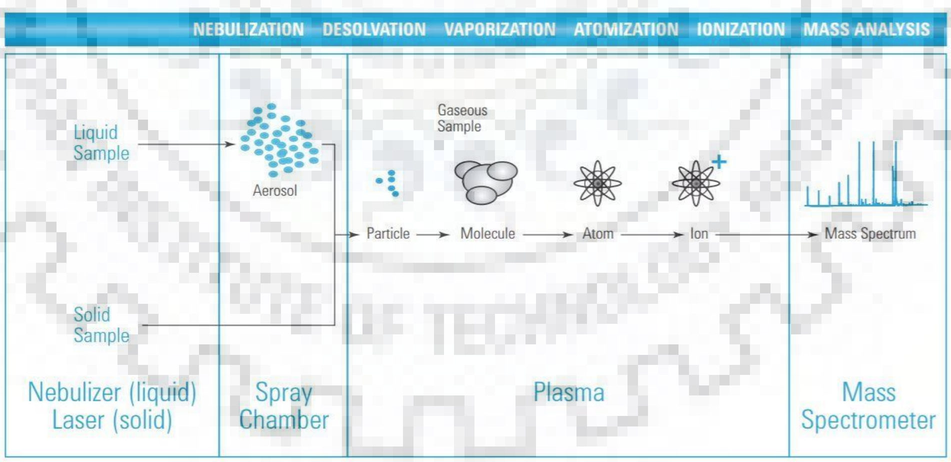


Fig.5.4.2b Process of metal detection in ICP-MS

5.3 RESULTS AND DISCUSSION

5.3.1.1The Result of Heavy Metals Detection (Pre Monsoon)

From the result (Fig 5.3.1.1), it had been observed that the traces of the elements like Iron(Fe), Arsenic(As) and Magnesium(Mg) are much more as compared to Selenium(Se), Chromium(Cr), Copper(Cu) Manganese(Mn), Cadmium(Cd) and Lead(Pb). From the analysis of the leached water sample, it had been observed that the agricultural land of the Jajmau area of Kanpur is contaminated, the traces of elements of Fe, Al and Mg are much high. The traces of different elements of soil samples are in parts per million (ppm) as shown in fig.6a are such as Cr 0.006-0.01 ppm, Fe 0.38-3.0 ppm, Se 0.7-0.85 ppm, As 25-55 ppm, Pb 0.01-0.25 ppm, Cu 0.005-0.01 and Cd is much less as compared to other elements.

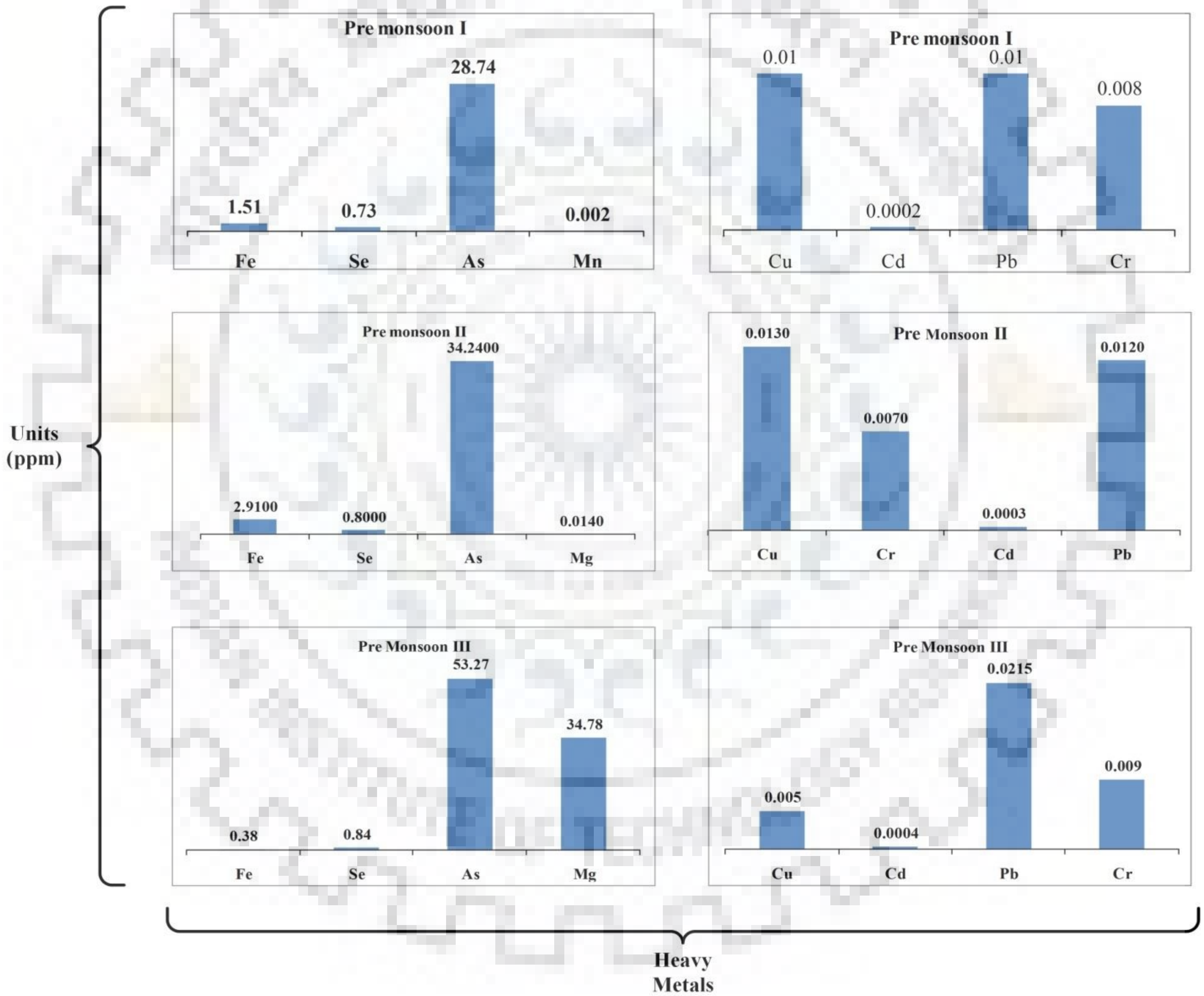


Fig.5.3.1.1a: Concentration of different elements in pre monsoon soil sample.

5.3.1.2 The result of Heavy Metal Detection (Monsoon)

From the graph (Fig.5.3.1.2) of monsoon sample analysis, it had been observed that the traces of elements in agricultural land in Jajmau area are such as Mg 18-94 ppm, As 25-42 ppm, Fe 6-9 ppm, Cr 0.7-1ppm, Se 0.8-0.83 ppm, Cu 0.06-0.07 ppm, Pb 0.02-0.04ppm and Mn 0.03-0.05ppm ,whereas traces of Cd presence indistinct amount. From the test results, it has been concluded that the traces of magnesium and arsenic are much high as compared to other elements like iron, chromium, lead, Selenium, Copper, and Manganese.

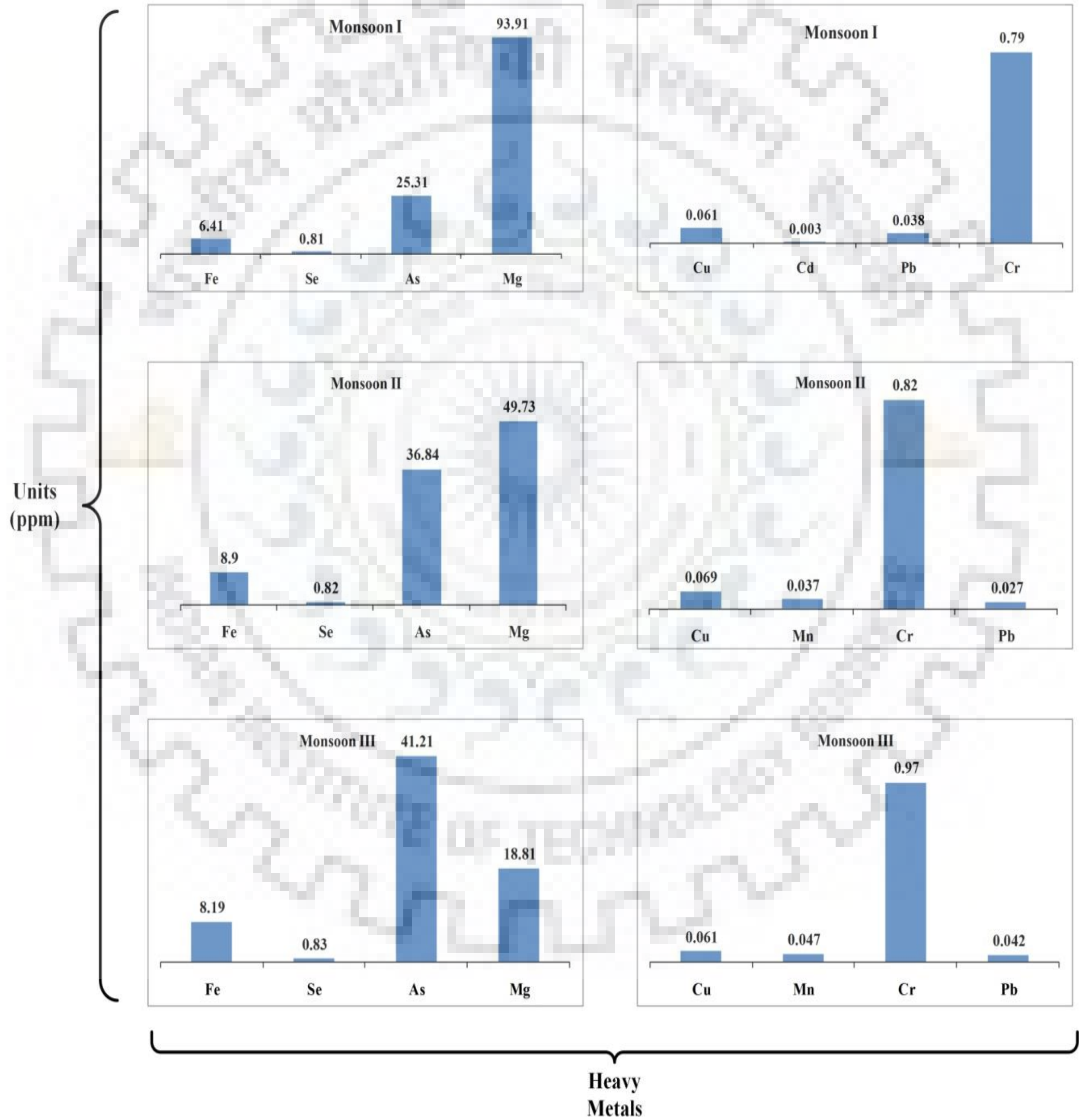


Fig.5.3.1.2b: Concentration of different elements in the monsoon soil sample.

5.3.1.3 The result of Heavy Metals detection (post-monsoon)

From the result, as shown below Fig.5.3.1.3, it had been observed that the traces of different are such as As 67-109 ppm, Mg 0.49-32 ppm, Fe 3-46 ppm, Cr 0.04-3ppm, Se 0.6-1.58 ppm, Cd 0.007-0.29 ppm, Pb 0.012-0.8ppm, Cu 0.1-.4 ppm, and Mn 0.13 ppm. It has been observed that the traces of Arsenic, Iron and Magnesium are much high as compared to other elements. In post monsoon result Fe is much higher as compared to pre-monsoon and monsoon results.

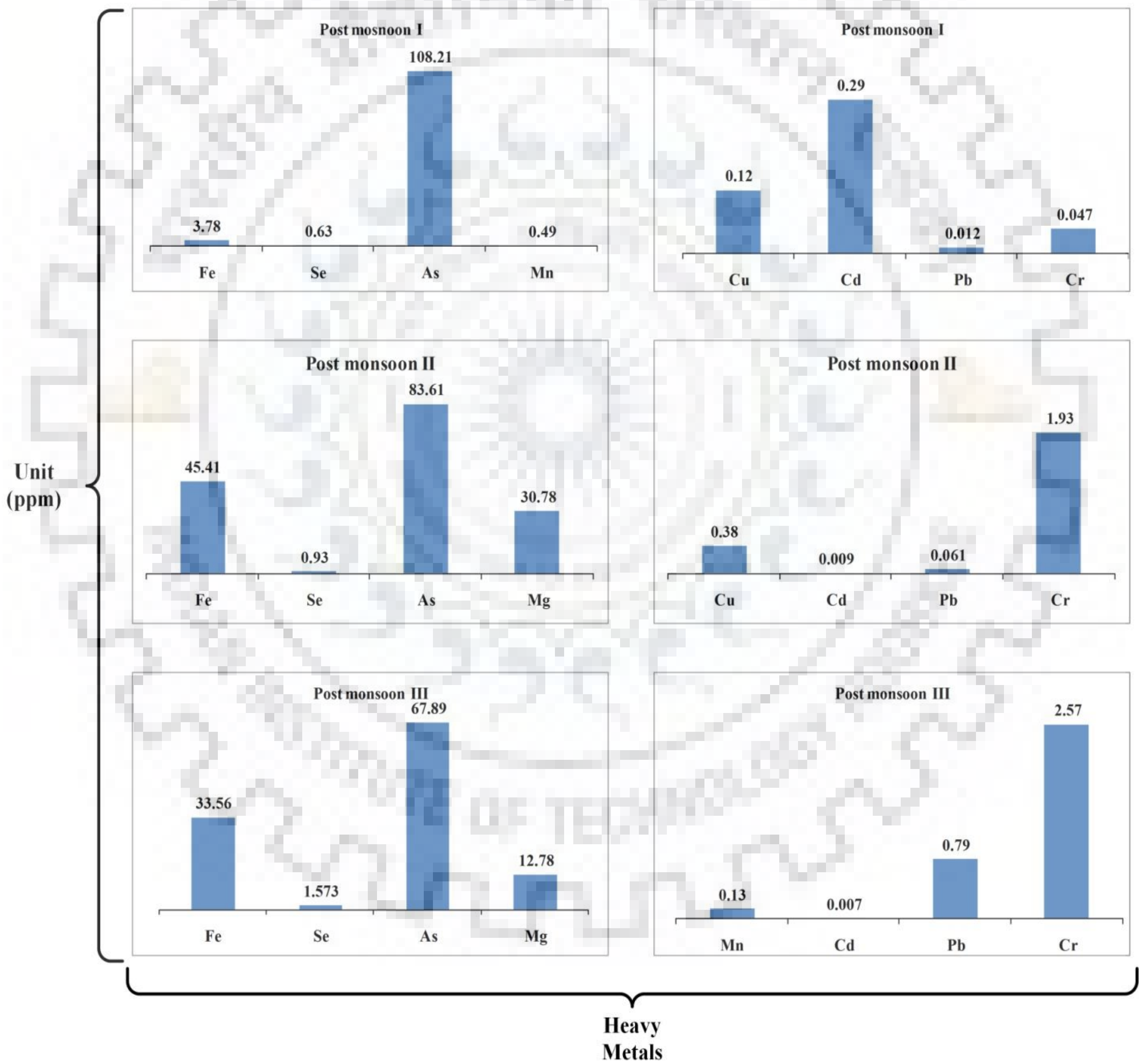


Fig.5.3.1.3c: Concentration of different elements in soil sample post monsoon.

5.3.2 Discussion

The presence of elements like As, Fe, and Mg in agricultural land, it shows that the land is unsuitable for any type of cropping pattern. The agricultural land in the Jajmau area being irrigated by improperly treated tannery effluent for many years hence results in agricultural land in that area were highly contaminated. From the results, it has been concluded that the soil samples collected in three different season traces of As and Mg were remaining in excess amount. Minimum As is 25.31 ppm during Monsoon season sampling and Maximum As is 108.21 ppm during post-monsoon sampling, for Mg Min 0.014 ppm and Max 93.91 ppm. According to the UN report, Soil has a great potential to filter and buffer contaminants, degrading and attenuating the negative impact of pollutants, but this capacity is finite. Most of the pollutants originate from human activities, such as industrial activities, Unsustainable farming activities and mining, untreated urban waste and other non-environmental friendly practices.

5.4 CONCLUDING REMARKS

The main adverse impact of soil contamination is food safety, which can not only affect the nervous system but also induce kidney, liver and bone damage, says a report published by Food and Agricultural Organization (UN Report May 2018). "Soil pollution affects the food we eat, the water we drink, the air we breathe, and the health of our ecosystem," said Maria Helena Semedo, FAO Deputy Director-General. Heavy metals mostly enter the food chain through absorption by plant roots (Brevik .et .al 2013) It goes on effect to, for human, presence of Cadmium, which is one of the toxic elements for humans as it can “penetrate during pregnancy, damaging membranes and DNA and disrupting the endocrine system, and can induce kidney, Liver and bone damage” (Burgess .et .al 2013). Now talk about the Lead, report says that the earlier researches have shown that lead affects several organs, causing a biochemical imbalance in the liver, kidney, spleen, and lungs causing neurotoxicity, mainly in infants and children (Jordao .et .al 2006). Rather than consuming crops that grown in contaminated soil, the ways in which people can come in contact with contaminated soil are ingestion, dermal exposure, from using spaces such as parks and gardens or by inhaling soil contaminants that have been vaporized.

CHAPTER 6: UPGRADATION OF STP (SEWAGE TREATMENT PLANT) THROUGH POWER GENERATION TECHNIQUE

6.1 GENERAL

The proper disposal of waste effluent generated from different source becoming a challenge for the people. To overcome such challenges, the construction of Sewage Treatment Plant for domestic effluent and Effluent treatment Plant (ETP) for Industrial effluent becomes necessity for the waste management authorities. Now, with the time challenges get change, the operation and maintenance of STP and ETP plants becomes tough for the management authorities. On looking forward to the new challenges is being faced by the authorities, this study had been done. This study is being done on STP plant situated Bingawa area of Kanpur city. To reduce the operation and maintenance cost of a STP plants, the idea of power generation by using turbines at outlet channel and using solar panels to generate the power and to store it properly. So, that stored power can be utilized in operating the plant.

6.2 POWER CALCULATION

6.2.1 Using Turbines at the Outlet Channel

After, the detail study of the STP plant, it is suggested to place Kaplan turbines at the drop h and Water current turbine directly into channel.

6.2.1.1 Kaplan Turbine

Kaplan turbine evolved from the Francis turbine, and is known for the efficient production of power in considerably lower head application scenarios that were not possible in Francis turbine. Kaplan turbine rotates very quickly, up to nearly four hundred fifty revolutions per minute, where as large Kaplan turbines have the potential to create enough hydroelectric power up to five million household a year (Kuhl et. al 2014). This is the equivalent of twenty million barrels of oil, or nearly ten million metric ton of carbon dioxide emissions. Together with its variable head, Kaplan turbines can produce and output ranges from few kilowatts (KW) to 230 Megawatts (MW).

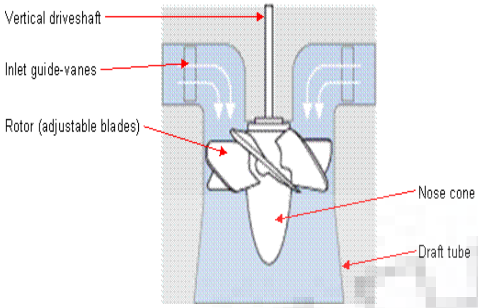


Fig.6.2.1a Layout of Kaplan Turbine **Fig.6.2.1b** Drop at the end of outlet channel

Fig.6.2.1c Front view of drop at outlet c/h

6.2.1.2 Calculation for Kaplan turbine

The monthly discharge variation at the outlet of the STP Plant is as shown below

MONTH	DISCHARGE (m3/sec)
Jan	1.9
Feb	1.8
Mar	1.8
Apr	1.8
May	1.9
Jun	1.9
Jul	2.4

Aug	2.2
Sept	2
Oct	1.8
Nov	1.7
Dec	1.9

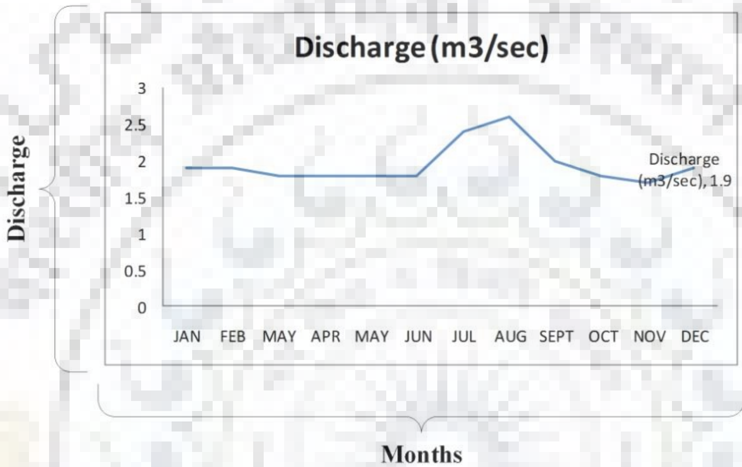


Fig.6.2.1.2a Monthly discharge variation

Power output is determined by following expression

$$P=npqgQH$$

Where P is mechanical Power produced by the turbine (KW),

Q Discharge (m3/sec)

H Net effective Head

n efficiency of the turbine (including generator) for Kaplan turbine n1=0.93 and generator n2=0.95

p is the density of water (kg/m3)

g acceleration due to gravity (m3/sec)

H is 2.5 meter, n=n1Xn2, p 998 kg/m3, g 9.81 m/sec2

6.2.1.3 Water Current Turbines

Water Current turbines, or hydrokinetic turbines, produce electricity directly from the flowing water in a river or stream. The energy flux of the water stream is dependent on the density of the, cross sectional area and velocity cubed. Several hydroelectric conversion concepts developed through the years. The two most common concept of hydroelectric turbine are axial flow turbine and cross flow turbine. The axial flow turbine has a rotational axis rotor which is parallel to the incoming water stream. The cross flow concept on the other hand, rotational axis of rotor which is parallel water surface, but orthogonal to the coming water stream.

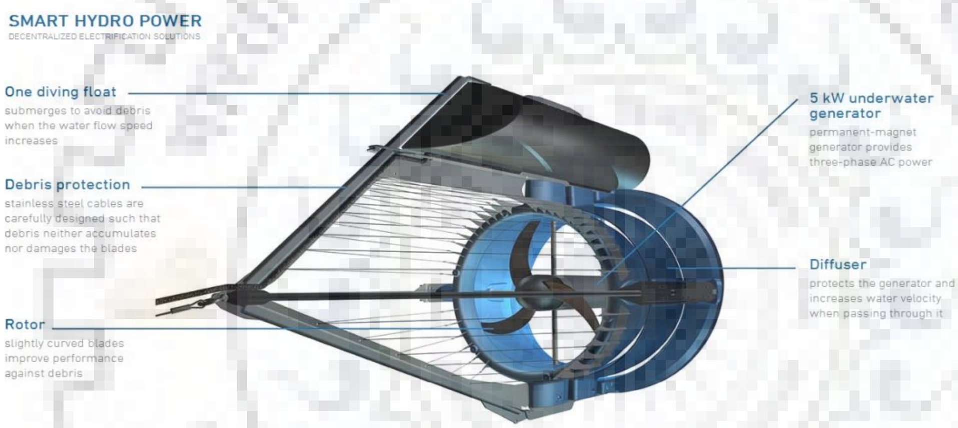


Fig.6.2.1.3 Structure of water current turbine

On the basis of the velocity, how much will get generated experimental information. The below data is given by the company,

VELOCITY (m/sec)	POWER (Watt)
1	0
1.25	250
1.5	800
1.75	1250
2	1850
2.25	2500
2.5	3500
2.7	4500
2.8	5000

6.2.2 Using Solar Panels

For design of the solar plant for a STP plant, the following points are given below (Energy Gov report USA)

- Investigate your home's energy efficiency (Aware of total electricity usage).
- Assess your solar potential and any limitations (The amount of Solar Power generated by solar energy system depends on how much sun energy reaches it).
- Estimate your solar electricity needs (Total load calculation according to your usage).
- Obtain bids and site assessment from the solar installer.
- Understand the available financing and incentives from the government.

After the proper study and site visit, the total load calculation (approximate) is shown below

S.NO	**Description**	**Quantity**	**Working**	**Motor (KW)**	**Load Cal.(KW)**
1	Mechanical Bar Screen	3	3	3.7	11.1
2	Conveyor for Mech Bar Screen	1	1	1.5	1.5
3	Grit Separator				0
4	Main Drive, Classifier Drive, Organic Pump	4 each	4 each	1.5	6
5	**Aerator**	18	12	7.5	135
6	**Belt Filter** Press	3	2	-	0
7	Inlet Box Agitator, Hydraulic Pump, Main Drive, Filtrate Pump, Filter press belt wash pump,	3 3 3 2 1	2 2 2 1 1	0.37 5.5 5.5 3.7 15	1.11 16.5 16.5 7.4

	Sludge pump feed to belt filter press, Filter press sludge holding tank agitator	3 1	2 1	7.5 2.2	15 22.5 2.2
8	**Poly electro dosing tank agitator**	1	1	1.1	1.1
9	**Poly electro dosing pump**	3	2	0.55	1.65
10	**Chlorination system booster pump**	2	1	7.5	15
11	**Drain Pump**	2	2	3.7	7.4
		Total			**268.96**

The approximate load calculation of total STP plant is 268.96 KW, Design of solar power plant must be done by considering the load on higher side. The plant is to run 24 hours, the availability of the sun intensity approximately 9 hours out of which peak intensity is 4 hours approximately. So, to full fill the demand during remaining 13 hours when Sun is not available, The Plant will design on 1.5 times more than the calculated load.

Fig.6.2.2a Panel for filter press belt

Fig.6.2.2b Starter for filter press belt

Fig.6.2.2c Surface aerator for aerobic process

6.2.3 RESULTS AND DISCUSSION

6.2.3.1 Power Generated from turbines

Table.6.2.3.1 Discharge per day(m3/sec) and Power

DAY	DISCHARGE (m3/sec)	POWER (KW)
1	1.9	41
2	1.8	39
3	1.8	39
4	1.8	39
5	1.9	41
6	1.9	41
7	1.9	41
8	1.8	39
9	1.8	39
10	1.8	39
11	1.9	41
12	1.9	41
13	1.8	39
14	1.9	41
15	1.7	37
16	1.8	39
17	1.9	41
18	1.7	37
19	1.8	39
20	1.9	41

21	1.6	35
22	1.7	37
23	1.9	41
24	1.8	39
25	1.8	39
26	1.8	39
27	1.8	39
28	1.7	37
29	1.9	41
30	1.9	41

Net Head (H)= 2.5 meter, Overall efficiency (n)= 0.88, Density(p)=998kg/m3 and Q discharge in a month the average power will generate from turbine 39 Kilo water in one month. Hence, proper head will be needed at drop point inside the channel.

6.2.3.2 Power Generated from Water Current Turbine

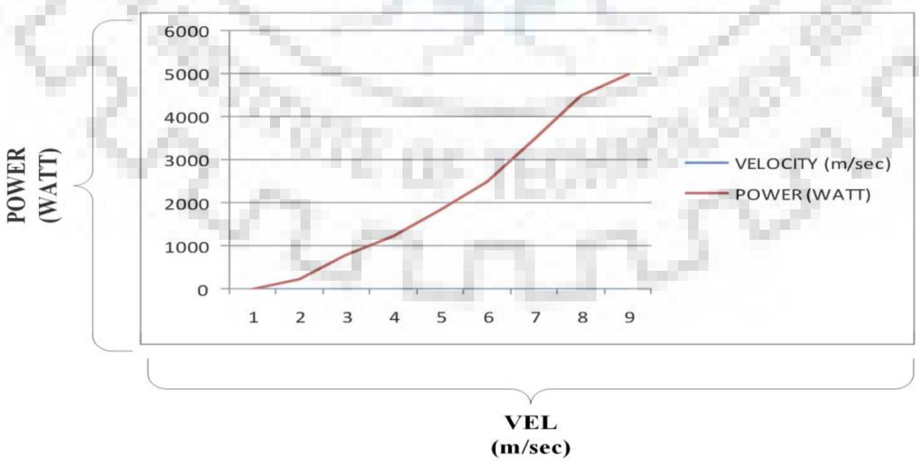


Fig 6.2.3.2 Output power from water current turbine on the basis of velocity of flow

From the graph as shown in Fig 6.2.3.2, It has been concluded that the **minimum power** will be 0 watt at 1m/sec flow velocity and **maximum power** will be 5000 watt at 2.8 m/sec of flow velocity.

6.2.3.3 Capacity of the solar on the basis of the Load

Total load calculated above is 268.96 KW, But the Solar plant will be design on more than the calculated load nearly about 1.5 times. Solar plant will be on grid plant system, battery system solar plant will not suitable. The reason for taking higher load than the calculated is that STP plant will run for 24 hours and during non sun hours extra load will be require for unterrupted power supply

CHAPTER 7: CONCLUSION AND RECOMMENDATION

7.1 GENERAL

Based on the research study of the three objectives as mentioned in 1.3.2, First objective study concluded that the open drains in the cities releasing domestic and industrial effluent directly into the Ganga River. The continuous releasing of domestic and industrial effluent from drains into the river is increasing the pollution level of the river day by day. To study the pollution level in Ganga River, three major populated cities were selected; within the each city drain releasing maximum discharge into Ganga River was identified. Seasonal sampling was performed from the drain location of each city, with help of these samples different water quality parameter of Ganga River measured and analyzed. The industrial drain of Wazidpur area of Kanpur is completely taped now at present time under Namami Gange Program as shown in fig.7.1a and b.

Fig.7.1a Wazidpur Industrial Drain July 2018 **Fig.7.1b** Wazidpur Industrial Drain March 2019

In second objective land contamination of agricultural is being discussed, Jajmau area is selected for the study of contamination. There are maximum numbers of tanning industries are established in Jajmau area. The three seasonal soil samples were collected from the agricultural field and the leaching process were performed on each seasonal samples. After that the ICP-MS test was done. It was concluded from the result that the presence of heavy metals in the agricultural land.

In the last objective of the project is that to generate power in STP plant to reduce the per month electricity cost of plant, which in turns reduce operation and maintenance of STP plant. After the proper study of the plant, It was suggested the use of low head turbine (Kaplan Turbine) and River

Turbine to generate power, On the basis of the load calculation of the STP plant power generation through solar technology can be suggested.

7.2 CONCLUSION

Following conclusion can be drawn from the study.

7.2.1 Health Assessment of Ganga River along Major cities.

- The industrial and domestic drain releasing the effluent into the river increasing the pollution level of the river, which results in degradation of quality of river and also disturb the ecosystem of the environment.
- After testing the river samples of different season, It was found the water quality parameters of the river vary according to the seasonal variation.
- According to the flow in river the pollution level varies, for example In Haridwar Ganga River, flow is high as compared to Kanpur and Prayagraj, which results in water quality of Ganga River in Haridwar, is better than other two cities.
- The water quality parameter test follows standard method as directed by American Public Health Association, American Water Works Association and Water environment federation.
- The test value of the elements more than the permissible limit, indicates the pollution in Ganga Kanpur post monsoon at confluence point As 3.439ppm,Cr 4.851ppm and Fe 3.026ppm, permissible limits As 0.05ppm, Cr 0.05ppm and Fe 0.3ppm. Similarly for Prayagraj post monsoon at confluence point As 15.074ppm, Cr 0.015 and Fe 12.69ppm, In Prayagraj due to degraded land along the banks of the Ganga River is the main reason for the presence of heavy metals. Haridwar post monsoon metals traces at confluence point As 2.042ppm, Fe 0.69ppm and Cr 0.03ppm.

7.2.2 Contamination in Agricultural land in Jajmau area.

- Seasonal soil samples were collected, after testing of each sample the presence of elements were identified especially Arsenic (As), Magnesium (Mg) and Iron (Fe) were present in excess amount. At Pre monsoon sample As 53.27ppm, Mg 34.78 ppm, Fe 2.9ppm, Monsoon As 41.21ppm, Mg 49.73ppm and Fe 8.19ppm and Post Monsoon Season Sample As 108.21 ppm, Fe45.41ppm and Mg 30.78.

- Using improper treated industrial effluent for irrigation purposes since a long time, results of contamination in soil.
- The contaminated soil also results the ground water contamination due to percolated water through the soil.
- The food crops grown on such type of land will leads to various types of diseases like that lead affects several organs, causing a biochemical imbalance in the liver, kidney, spleen, and lungs causing neurotoxicity, mainly in infants and children.

7.2.3 Power Generation Technique in STP Plant

- There are two techniques were suggested for power generation are
  (i) By using turbines at the outlet channel of STP plant
  (a) Kaplan Turbine
  (b) Water Current Turbine
  (ii) By use of solar panels.
- Calculation of power generation is depending on the flow (discharge) in the channel in case Kaplan turbine, average power generation nearly 39 KW. Whereas in case water current turbine the power generation is depend on the velocity of flow in the outlet channel, The power generation are minimum 0 W at 1m/sec and maximum 5000 W at 2.8m/sec
- On the basis of the total calculated load, design capacity of the solar plant system will decided.
- Solar plant system will be designed on grid power system, Total calculated loads are 268 KW and Solar system design capacity will be 375 KW.

7.3 SCOPE FOR FUTURE STUDY

7.3.1 Health Assessment of Ganga River

- Identify the location of other drains having high discharge in the above mention study area. So, that assessment of that drain will be performed as similar way as mention in the report.
- For the more accurate assessment of Ganga River frequent sampling at same location can

be done and tested.

- The tests like fecal coli form test and MPN test need are not performed, Due to unavailability of the setup, These tests to be performed to know more about pollution level in Ganga River

7.3.2 Contamination in Agricultural Land.

- More soil samples require for more accurate study of contamination.
- More number of leached water samples through the soil require to test.
- For the reference the soil sample collection from the different place need to be collected, So that the comparisons can be done between the two soil samples .

7.3.3 Power Generation techniques in STP plant.

- The economical study or feasibility of the power generation of the above three techniques require to study.
- The effect water flux in case of water current turbine requires to study.
- More detail study require before solar plant installation.

REFERENCES

Schwarzenbach, R.P. Egli, T. Hofstetter, T.B., Von Gunten, U. and Wehrli, B., 2010. Global water pollution and human health. *Annual Review of Environment and Resources*, *35*, pp. 109-136.

Zhang, C., Qiao, Q., Piper, J.D. and Huang, B., 2011. Assessment of heavy metal pollution from a Fe-smelting plant in urban river sediments using environmental magnetic and geochemical methods. *Environmental Pollution*, *159* (10), pp.3057-3070.

Rehana, Z., Malik, A. and Ahmad, M., 1995. Mutagenic activity of the Ganges water with special reference to the pesticide pollution in the river between Kachla to Kannauj (UP), India. *Mutation Research/Genetic Toxicology*, *343*(2-3), pp. 137-144.

Mwinyihija, M.,2010. Main pollutants and environmental impacts of the tanning industry. In *Ecotoxicological diagnosis in the tanning industry* (pp. 17-35). Springer, New York, NY.

Tewari, A., Dubey, A. and Singh, P., 2012. Impact of tanning industries on ground water resources. *Journal of Environmental Research And Development Vol*, *6*(3A).

Singh, K.P., Malik, A., Mohan, D. and Sinha, S., 2004. Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India)— a case study. *Water research*, *38*(18), pp.3980-3992.

Singh KP, Basant A, Malik A, Jain G. Artificial neural network modeling of the river water quality—a case study. Ecological Modelling. 2009 Mar 24;220(6):888-95.

God, S.S., Reddy, M.R., and Govil, P.K., 2010. Assessment of heavy metal contamination in soils at Jajmau (Kanpur) and Unnao industrial areas of the Ganga Plain, Uttar Pradesh, India. *Journal of Hazardous Materials*, *174*(1-3), pp.113-121.

Sharma, R.K., Agrawal, M. and Marshall, F., 2006. Heavy metal contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. *Bulletin of environmental contamination and toxicology*, *77*(2), pp.312-318.

Vos, T., Abajobir, A.A., Abate, K.H., Abbafati, C., Abbas, K.M., Abd-Allah, F., Abdulkader, R.S., Abdulle, A.M., Abebo, T.A., Abera, S.F. and Aboyans, V., 2017. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *The Lancet*, *390*(10100), pp.1211-1259.

Batsala, M., Chandu, B., Sakala, B., Nama, S. and Domatoti, S., 2012. Inductively coupled plasma mass spectrometry (ICP-MS). Int J Res Pharm Chem, 2(3), pp.671-680.

Montaser, A. ed., 1998. Inductively coupled plasma mass spectrometry. John Wiley & Sons.

Taylor, V.F., Longerich, H.P. and Greenough, J.D., 2003. Multielement analysis of Canadian wines by inductively coupled plasma mass spectrometry (ICP-MS) and multivariate statistics. Journal of Agricultural and Food Chemistry, 51(4), pp.856-860.

Brevik, E.C., 2013. Forty years of soil formation in a South Georgia, USA borrow pit. *Soil Horizons*, *54*(1), pp.20-29.

Burgess, R.J. and Zhang, Z., 2013. Histone chaperones in nucleosome assembly and human disease. *Nature structural & molecular biology*, *20*(1), p.14.

Jordao, C.P., Nascentes, C.C., Cecon, P.R., Fontes, R.L.F., and Pereira, J.L., 2006. Heavy metal availability in soil amended with composted urban solid wastes. *Environmental Monitoring and Assessment*, *112*(1-3), pp.309-326.