Project Completion Report (Final)

ACTION RESEARCH ON IWRM PLAN FOR WATER SECURITY IN IDENTIFIED VILLAGES OF WESTERN U.P.

(REJUVENATION OF IDENTIFIED VILLAGE PONDS IN MUZAFFARNAGAR AND MEERUT DISTRICTS)

(Sponsored by INC-SW, Ministry of Jal Shakti)

NATIONAL INSTITUTE OF HYDROLOGY
JAL VIGYAN BHAWAN
ROORKEE - 247 667
(2017-2020)

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1.0 DETAILS OF THE PROJECT

TITLE OF THEPROJECT

Action Research on IWRM Plan for Water Security in Identified Villages of Western U.P.

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2.0 FINANCIAL DETAIL

The final SE of the pond project is given below:

Statement of Expenditure as on 08.05.2020

MOWR-PONDS **ACTION RESEARCH ON IWRM PLAN FOR WATER SECURITY IN IDENTIFIED VILLAGES OF WESTERN UP, 13.04.2017, TOTAL COST-83000000/-**

S.NO.	SP-23/2017-18/RMOD				
	PI-DR. V.C.GOYAL, SC. G				
	DURATION				
	TOTAL COST	83000000			
	FINANCIAL YEAR	2017-18	2018-19	2019-20	TOTAL
	GIA-RECEIVED	40000000	0	20000000	**60000000**
	INTEREST EARNED	0	429165	24384	**453549**
	INTEREST DEPOSITED TO BHARATKOSH		-429165	-24384	**-453549**
		0	0		**0**
	TOTAL	40000000	0	20000000	**60000000**
	EXPENDITURE INCURRED	**2017-18**	**2018-19**	**2019-20**	
	SALARIES INCLUDING COMMITMENT	1955213	2798214	2353875	**7107302**
	POND WORK BY NPCC			76067659	
	TRAVEL EXP.	98461	219582	204465	**522508**
	CONSUMABLE	12600	524878	252006	**789484**
	SAMPLE ANALYSIS	47151	637200		**684351**
	CONTINGENCY	24223	17057	14100	**55380**
	AUDIT FEES PAID	0	2036	2596	**4632**
	AUDIT FEES PROVISION			2856	
	EQUIPMENT			77640	**77640**
	TOTAL EXPENDITURE	2137648	4198967	78975197	**85311812**
	CLOSING BALANCE	**37862352**	**33663385**	**-25311812**	**-25311812**
	NET BALANCE	37852352	1633019	-25311812	**-25311812**
	LIABILITIES (NPCC & NIH)	43500	146160	25316327	**25316327**
	BALANCE AS PER CASH BOOK	**37895852**	**1779179**	**4515**	**4515**

Total Liabilities	
NPCC Balance Payment	25047379
Wages Payable (127599+138493)	266092
Audit Fees Payable	2856
Total Liabilities	**25316327**

वित्त अधिकारी/Finance Officer
राष्ट्रीय जलविज्ञान संस्थान
National Institute of Hydrology
रुड़की/Roorkee

3.0 UTILIZATION CERTIFICATE (Final)

FORM GFR 12A

GENERAL FINANCIAL RULES 2017
Ministry of Finance
Department of Expenditure

GFR 12 – A

[(See Rule 238 (1)]

FORM OF UTILIZATION CERTIFICATE

FOR AUTONOMOUS BODIES OF THE GRANTEE ORGANIZATION

UTILIZATION CERTIFICATE FOR THE YEAR 2019-20 (as on 08.05.2020)

in respect of Recurring/Non-Recurring

GRANTS-IN-AID/SALARIES/CREATION OF CAPITAL ASSETS

1. Name of the Scheme: **Action research on IWRM plan for Water Security in Identified villages of Western UP (sanction vide letter no. 15/01/2017-R&D/638-648 Dated 13.04.2017, DoWR, RD&GR under INCSW)**
2. Whether recurring or non-recurring grants: " Recurring & Non-Recurring"
3. Grants position at the beginning of the Financial year 2019-20:
   - (i) Cash in Hand/Bank: Rs. 17,79,179/-
   - (ii) Unadjusted advances (to NPCC): Rs. 3,20,30,366/-
   - (iii) Liabilities: Rs. 1,46,160/-
   - (iv) Total (i+ii-iii): Rs. 3,36,63,385/-
4. Details of grants received, expenditure incurred and closing balances: (Actuals)

Unspent Balances of Grants received years [Figure as at Sl. No. 3 (iv)]	Interest Earned thereon	Interest deposited back to the Government	Grant received during the year			Total Available funds (1+2-3+4)	Expenditure incurred (i/c liability)	Closing Balances (5-6)
1	2	3	4			5	6	7
			Sanction No. (i)	Date (ii)	Amount (iii)			
3,36,63,385/-	**24384/-**	**24384/-**	**No. 15/1/2017-R&D (Pt.)/ 935-947**	**Sept 23, 2019**	**2,00,00,000/-**	**5,36,63,385/-**	**7,89,75,197/-**	**-2,53,11,812/-**

Component wise utilization of grants:

Grant-in-aid– General (Rs.)	Grant-in-aid– Salary (Rs.)	Grant-in-aid–creation of capital assets (Rs.)	Total (Rs.)
7,65,43,682/-	**23,53,875/-**	**77,640/-**	**7,89,75,197/-**

Details of grants position as on 06.05.2020

- (i) **Cash in Hand/Bank: Rs. 4,515/-**
- (ii) Unadjusted Advances : 0
- (iii) *Liabilities (NPCC+NIH): Rs. 2,53,16,327/-
- (iv) Total (i+ii-iii): Rs. -2,53,11,812/-

***Liabilities: (a) NPCC= Rs. 2,50,47,379, (b) NIH= Rs. 2,68,948**

Certified that I have satisfied myself that the conditions on which grants were sanctioned have been duly fulfilled/are being fulfilled and that I have exercised following checks to see that the money has been actually utilized for the purpose for which it was sanctioned:

(i) The main accounts and other subsidiary accounts and registers (including assets registers) are maintained as prescribed in the relevant Act/Rules/Standing instructions (mention the Act/Rules) and have been duly audited by designated auditors. The figures depicted above tally with the audited figures mentioned in financial statements/accounts.

(ii) There exist internal controls for safeguarding public funds/assets, watching outcomes and achievements of physical targets against the financial inputs, ensuring quality in asset creation etc. & the periodic evaluation of internal controls is exercised to ensure their effectiveness.

(iii) To the best of our knowledge and belief, no transactions have been entered that are in violation of relevant Act/Rules/standing instructions and scheme guidelines.

(iv) The responsibilities among the key functionaries for execution of the scheme have been assigned in clear terms and are not general in nature.

(v) The benefits were extended to the intended beneficiaries and only such areas/districts were covered where the scheme was intended to operate.

(vi) The expenditure on various components of the scheme was in the proportions authorized as per the scheme guidelines and terms and conditions of the grants-in-aid.

(vii) It has been ensured that the physical and financial performance under................. (name of the scheme has been according to the requirements, as prescribed in the guidelines issued by Govt. of India and the performance/targets achieved statement for the year to which the utilization of the fund resulted in outcomes given at Annexure – I duly enclosed.

(viii)The utilization of the fund resulted in outcomes given at Annexure – II duly enclosed (to be formulated by the Ministry/Department concerned as per their requirements/specifications.)

(ix) Details of various schemes executed by the agency through grants-in-aid received from the same Ministry or from other Ministries is enclosed at Annexure –II (to be formulated by the Ministry/Department concerned as per their requirements/specifications).

Date: 08.05.2020

Place: NIH, Roorkee.

Signature:
(Principal Investigator)
Name: Dr. V.C. Goyal,
Scientist G & Head-RMOD

Signature:
(Finance Officer)
(Head of the Finance)
वित्त अधिकारी/Finance Officer
राष्ट्रीय जलविज्ञान संस्थान
National Institute of Hydrology
रुड़की/Roorkee

Signature:
Name.......................................
Head of the Organisation

डॉ. जयवीर त्यागी/Dr. J. V. Tyagi
निदेशक/Director
राष्ट्रीय जलविज्ञान संस्थान
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4.0 STATEMENT OF EQUIPMENT PURCHASED

1. Plankton nets, items for Fabricating FW model
2. Chemicals and Glasswares

5.0 INTRODUCTION

Villages in western UP are facing stagnation of drains and choked ponds, which are in dire need of renovation so that the ponds are effectively utilized as a source of water security and groundwater recharge in the area. Once considered the lifeline of village economy, the ponds in present times give a pathetic look. Moreover, a good amount of the pond area as well as the catchment area have been encroached by the local inhabitants. In the present set-up, village ponds are generally filled with all sorts of waste from their catchment areas. Domestic wastewater and solid wastes are dumped into these ponds. Disposal of wastewater in the ponds is a major public health concern as the stagnant water smells bad and also leads to spread of many diseases. As a result, ponds have become dump yard and are no more used for drinking or bathing purposes or any other useful purpose. The groundwater recharge from these ponds is also contaminating the local aquifers.

It is widely recognized that the encroachment, destruction of ponds/tanks/water bodies leads to acute shortage of water and rapid depletion of ground water and thereby affecting local availability of water for irrigation, drinking and consumption by livestock, besides affecting aquatic flora and fauna and accordingly there is an urgent need for protection, conservation, development, redevelopment and rejuvenation of water bodies. Since these ponds/tanks have socio-economic relevance to the society, there is a need to restore their entity with proper cultural fascination and suitable technical expertise, and the Uttar Pradesh Government is considering enacting a “Pond Development, Protection and Conservation Authority Bill (2017)” for this purpose.

This study aims towards rejuvenation of identified ponds in a retrofitting mode by carrying out de-weeding, de-silting, wastewater treatment and strengthening of the embankments. The inlet to the ponds will be treated through an appropriate Natural Treatment System (NTS) technology, such as Floating Wetlands (FW), to bring down the contaminants concentration, more particularly organics and nutrients. The rejuvenated ponds with treated wastewater shall then be used for groundwater recharge, limited agricultural use, as well as for livelihood activities such as fishery.

6.0 OBJECTIVES & STUDY AREA

As per original project proposal, initially 10 village ponds were identified by the concerned stakeholders with the following objectives:

1. Assessment of water situation in the identified villages and carrying out water budgeting exercise with the respective GramPanchayats.
2. Rejuvenation of identified village ponds through appropriate Natural Treatment Systems.
3. Carry out technology demonstrations at farmers' fields, schools, etc. for awareness generation and capacity building of the localvillagers.
4. Development of IWRM Plan for the identifiedvillages.
5. Guidance and hand holding of Gram Panchayats for implementation of the IWRMPlan.

Vide note no. 66 dated 5.5.2017 and 77 dated 8.6.2017, MoS, MoWR, RD & GR (Annexure I), the total no. of village ponds were increased to 13. However, while conducting field investigations, the concerned Gram Pradhan and MoS representative suggested to rejuvenate only one pond at Mohammadpur Madan instead of two ponds. Hence, finally 12 ponds were suggested for rejuvenation (Table 6.1). As desired by the then MoS (MoWR), rejuvenation work of highly degraded village ponds as a matter of primary importance and utmost priority of the villagers, rejuvenation of 12 identified ponds was taken up under theaction research activity of IWRM Project and other secondary components of IWRM activities were dropped with the financial support from INCSW, MoJS, DoWR, Rd & GR, with the **revised objectives** as given below:

1. Assessment of water situation in the identified villages and carry out water budgeting exercise with the respective GramPanchayats.
2. Rejuvenation of identified village ponds through installation of appropriate Natural TreatmentSystems.
3. Carry out awareness generation and capacity building of the localvillagers.

Table-6.1: Priority list of Identified Village Ponds in the project area

Sr. No.	Village	Village ID	Block &District	Location	PondKhasra No.	Identified ponds	Pond Area (Ha)
1	Bhora Kalan	MN - 1	Shahpur, M.Nagar	29.390714°; 77.446661°	168	1	0.85
2	BhoraKhurd Pond No.1	MN - 2	Shahpur, M.Nagar	29.396421°; 77.466515°	440	1	0.94
3	Mohammadpur Madan Pond No. 2	MN - 3	Baghra, M.Nagar	29.444523°; 77.468680°	226	1	0.29
4	Biral	MN - 4	Budhana, M.Nagar	29.247980°; 77.353848°	640	1	1.85
5	Pavli Khas	ME - 1	Daurala, Meerut	29.068355°; 77.686094°	973/1	1	1.06
6	Itawa Pond No. 02 (Near Masjid)	MN - 5	Budhana, M. Nagar	29.224812°; 77.467710°	195	1	0.36
7	BhoraKhurd Pond No.2	MN - 6	Shahpur, M.Nagar	29.398626°; 77.467483°	405	1	0.79
8	Siwaya Jamalullapur	ME - 2	Daurala, Meerut	29.088818°; 77.708742°	513	1	0.74
9	Roni Hazipur	MN - 7	Charthwal, M.Nagar	29.543380°; 77.493092°	486	1	0.68
10	Antwara	MN - 8	Khatauli, M.Nagar	29.312605°; 77.787791°	540	1	0.35
11	Munnawarpur Kalan	MN - 9	Khatauli, M.Nagar	29.387868°; 77.742046°	291	1	0.27
12	Itawa Pond No.01(BademandirWala)	MN - 10	Budhana, M. Nagar	29.226693°; 77.465664°	212	1	0.69
	Total					**12**	**8.91**

All the ponds taken up for rejuvenation are located in Meerut and Muzaffarnagar districts of Western Uttar Pradesh (Figure 6.1).

Meerut district lies between 28°57' to 29°02' North latitude and 77°40' to 77°45' East longitude in the Indo-Gangetic plains of India. It is bound on the north by Muzaffarnagar district, in the south by Bulandshahar district while Ghaziabad and Baghpat districts form the southern and western limits. The river Ganges forms the eastern boundary and separates the district from Moradabad district and Bijnor district. The Hindon forms the western boundary and separates the district from Baghpat. As per 2011 census, the district had population of 3,443,689 of which male and female were 1,825,743 and 1,617,946 respectively. The ground is not rocky and there are no mountains. The soil is composed of pleistocene and sub-recent alluvial sediments transported and deposited by river action from the Himalayan region. These alluvial deposits are unconsolidated. Lithologically, sediments consist of clay, silt and fine to coarse sand. Land is very fertile for growing crops, especially wheat, sugarcane and vegetables. Meerut has a monsoon influenced humid subtropical climate characterized by hot summers and cooler winters. Summers last from early April to late June and are extremely hot, with temperatures reaching 49°C. The monsoon arrives in lateJune and continues till the middle of September. The lowest temperature ever recorded is −0.4 °C, recorded on January 06, 2013. Rainfall is about 845 mm per annum, which is suitable for growing crops. Most of the rainfall is received during the monsoon. Humidity varies from 30 to 100%.

Muzaffarnagar district lies between north latitudes 29º 11' 30" and 29º 45' 15" and east longitudes 77º 3' 45"and 78º 7'. Muzaffarnagar is located at an elevation of 272 meters above sea level in the Doab region of Indo-Gangetic Plain. As per 2011 census, the district had population of 4,143,512 of which male and female were 2,193,434 and 1,950,078 respectively. Muzaffarnagar has a monsoon-influenced humid subtropical climate characterized by much hot summers and cooler winters. Summers last from early April to late June and are extremely hot. The monsoon arrives in late June and continues till the middle of September. Temperatures drop slightly, with plenty of cloud cover but with higher humidity. Temperatures rise again in October and the city then has a mild, dry winter season from late October to the middle of March. June is the warmest month of the year. The temperature in June averages 30.2 °C. In January, the average temperature is 12.5 °C. It is the lowest average temperature of the whole year. The average annual temperature in Muzaffarnagar is 24.2 °C. The rainfall here averages 929 mm. The driest month is November, with 8 mm of rain. Highest precipitation falls in July, with an average of 261.4 mm.

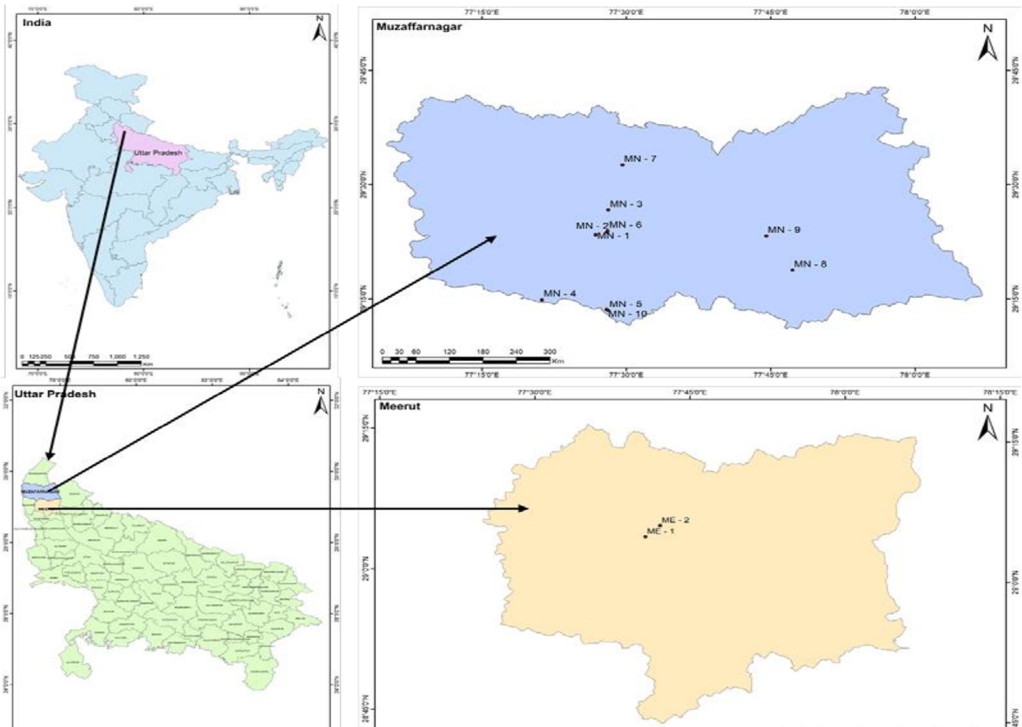


Figure 6.1: Study area and Location of Ponds under Rejuvenation

7.0 TIMELINE/MILESTONE

S. N.	Work Element/ Milestone	2017-18				2018-19				2019-20			
		I	II	III	IV	I	II	III	IV	I	II	III	IV
1	Data collection (baseline data of village/ community) for existing ponds and identification of suitable natural treatmentsystem												
2	Carry out water budgeting/reuse planning with the respective Gram Panchayats												
3	Groundwater level measurement around ponds												
4	Water/wastewater sample collection and analyses												
5	Rejuvenation of ponds by execution of civil works (dewatering, desilting, inlet works, outlet works, floating wetland)-through NPCC												
6	Nursery development *(plant species for floating wetland)* at NIH, Roorkee												
7	Performance evaluationof Natural TreatmentSystem												
8	Trophic State Analysis; assessment of Water Quality Index and Primary Production Capacity												
9	Capacity building, Mass Awareness & preparation of SOP work for operation &maintenanceof treatment system at rejuvenatedponds												
10	Submission of reports (Interim-progress reports and Final Project report)												

Completed

In Progress

8.0 METHODOLOGY

The basic objective of the rejuvenation of existing village ponds aims at restoring the functional status and enhancing the storage capacity of ponds so that these water bodies become effective as the instruments of water security at the village level. Once restored, these ponds contribute to the local groundwater recharge (with good quality water) and the treated pond water can also be used for limited irrigation purposes (such as agriculture, horticulture, floriculture), leading to improved livelihood for the local community.

The broad activity components of such works involve removing any weeds, accumulated sludge at the pond bottom, strengthening of pond embankment, and establishing an effective nature-based technology for the treatment of wastewater entering into the pond from the catchment area. Also, inlet and outlet works are established for handling the incoming wastewater and stormwater during monsoon.

The pond rejuvenation also involves assessing the physical and trophic status of ponds, before and post-renovation. This is achieved through detailed investigations comprising the monitoring of water quality of the pond water, the incoming wastewater, and the groundwater in nearby handpumps and wells. Factors contributing to the degeneration of the pond water quality are assessed by establishing the correlation among the various controlling parameters.

Besides, the storage capacity of the pond is estimated through bathymetry survey and infiltration rate is estimated through infiltration rate measurement on the pond bed. The research component of pond rejuvenation work includes the assessment of the quality of treated wastewater in terms of various designated uses, such as irrigation, fishery, etc.

8.1 Civil Work Component

In order to execute the civil work component of pond rejuvenation (i.e. dewatering, de-weeding, de-silting/removal of sludge, construction of sedimentation tank (with installation of floating wetlands), inlet/outlet works, periphery drains, provision of animal ramp), an MOU was signed with NPCC Ltd (A GoI Enterprises) on dated 19/02/2018. A Detailed Project Report (DPR) was prepared in consultation with NPCC, based on the preliminary survey and baseline measurement of the dimensions of the ponds.

8.1.1 Dewatering, Deweeding and Desilting of Pond

During the course of wastewater inlet into a pond and in absence of regular cleaning, a sludge layer is formed at the base of the pond. Over time, due to accumulation of the sludge, the effective volume of the pond reduces, impacting the pond ecosystem and self-cleansing capacity. Moreover, the sludge accumulated at the bottom of the pond is generally impermeable and hence restricts the groundwater recharge. Sludge removal and disposal is a necessary part of pond maintenance. Cleaning of sludge/desilting of the pond is carried out considering factors such as type of sludge, type of silt, and distance of a suitable location where the material removed from the pond will be disposed off.

8.1.2 PeripheryDrain

A periphery drain is built along the perimeter of the pond to bypass the stormwater runoff during monsoon season (Figure 8.1).

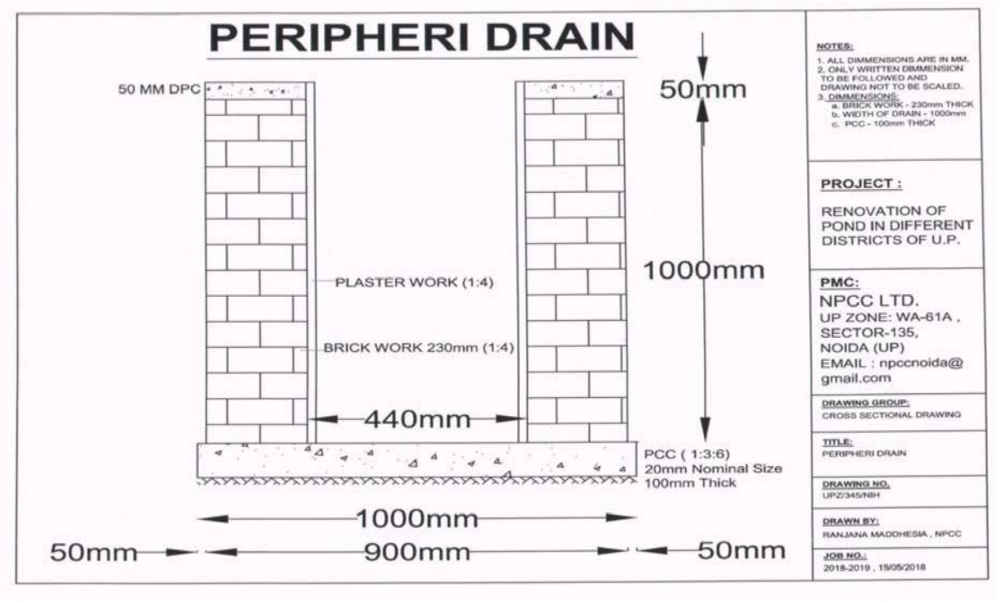


Figure 8.1: Design of Periphery Drain

8.1.3 Outlet Works

Outlet structures are built for two main reasons: (i) to keep the water surface in the pond at its optimum level, which usually coincides with the maximum water level designed for the pond, and (ii) to allow for the complete draining of the pond. The outlet design for the pond comprises of an outlet drain (OD) which removes the excess water when the water level in the pond reaches a pre-defined level to nearby agricultural fields.

8.1.4 Embankment of pond

Side walls/embankments of the ponds are strengthened through compaction of the excavated soil.

8.1.5 Inlet Design for Channelization of Wastewater (Including Screen bar, Grit chamber & Sedimentation tank)

Wastewater generated from households in the catchment area of the pond reaches the pond through naturallydefined channels. All kinds of waste material, including grit, silt, dairy-waste, etc. enter into the pond. Inlet structures are built to channelize the wastewater entering into the pond with screening of floating and grits particles at the entry stage. The need for an inlet structure varies with the type of water supply being used to feed the pond. Therefore, as a pre-treatment measure, a combination of inlet drain, grit chamber and sedimentation tank is designed for the pond**.** A 20m long inlet drain is designed to channelize the incoming discharge, and a screen is placed on the top of grit chamber to remove the large size solid waste material. A minimum Hydraulic Retention Time (HRT) is needed for effective treatment. The outflow from screening-cum-grit chamber enters into the sedimentation chamber after removing the physical impurities ***(Figure 8.2).*** The finer silt particles get settled down in the sedimentation tank, which is overlain by a natural treatment unit (Floating Wetland). The FW unit floats on top of the sedimentation tank, where it performs the final treatment of wastewater, and the treated wastewater enters into the pond through the outflow of this unit. The advantage of this arrangement is the settling of fine silt/sediments in the sedimentation tank, enabling the longer life of pond. After certain period, the sedimentation tank needs to be cleaned at much lower cost. The inlet excess water is diverted to pond (through inlet bypass) during monsoon season.

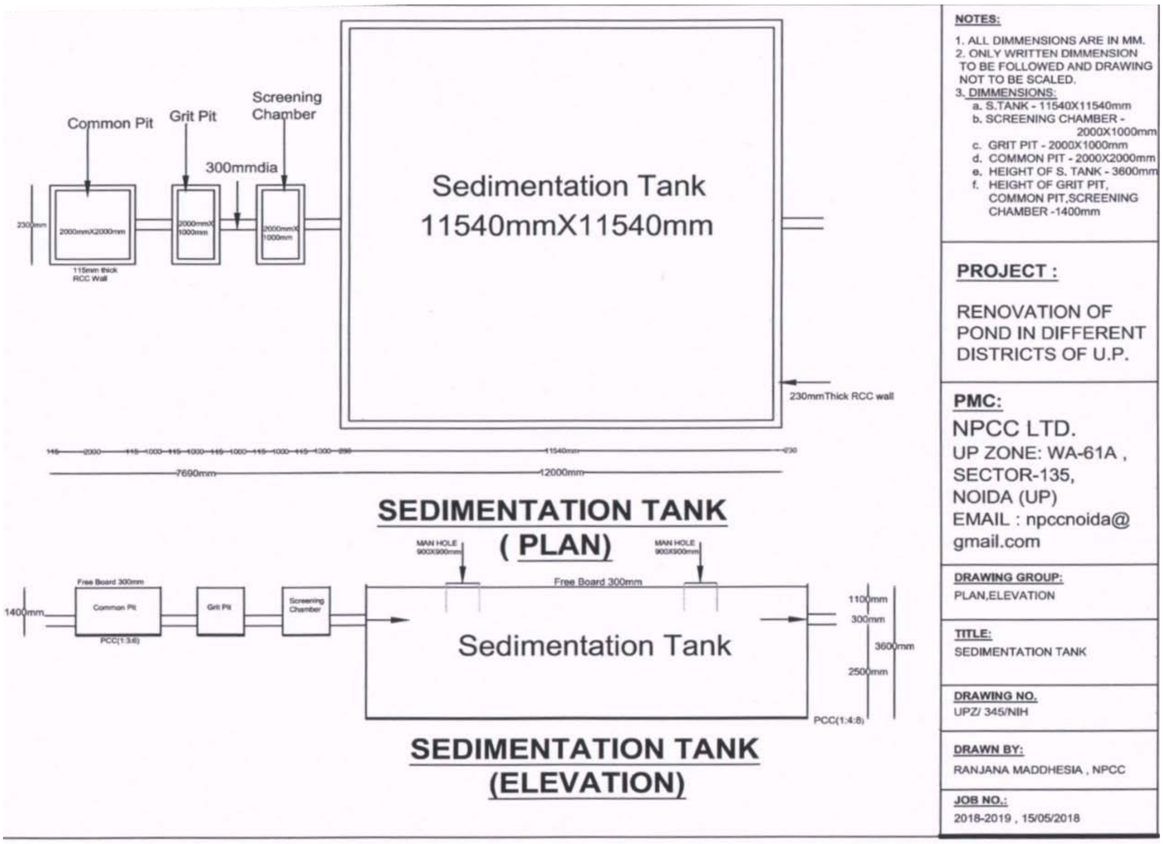


Figure 8.2: Pretreatment through Grit Chamber/Sedimentation Chamber

8.2 R&D Component

In order to carry out the proposed action research, assessment of the baseline health status of the ponds was considered essential. Using the baseline physico-chemical and biological data collected in the project, the ecological health and trophic status of the ponds was estimated in terms of various indices (e.g. TSI, Nygaard's Algal Index, Shannon-Weaver Diversity Index). Correlation analysis between physic-chemical and biological parameters was carried out to identify the driving factors responsible for eutrophication of the ponds. Landuse mapping around pond sites was conducted to aid in the planning of the use of treated pond water. A Water Sampling Protocol was designed for characterization of the pondwater, wastewater and groundwater from the pond sites (**Table 8.1)**.

8.2.1 Pondwater, Wastewater and Groundwater Characterization

Samples were collected from the pond, inlet to pond (wastewater), and handpumps in polyethylene bottles using dip/grab sampling method and preserved by using appropriate reagents as per standard methods (APHA, 2017). All glassware and other containers used for trace element analysis were thoroughly cleaned, soaked in 10% nitric acid for 48 h and finally rinsed with de-ionized water several times prior to use.

Table 8.1: Water Sampling Protocol

Trend Impact (Every 6 Months)		
Pond Water	**Wastewater**	**Groundwater**
a. General: pH, Electrical Conductivity, Turbidity, TSS, Total Dissolved Solids	**a. General**: pH,Electrical Conductivity, Turbidity, TSS, Total Dissolved Solids	**a. General**: pH,Electrical Conductivity, Turbidity, TSS, Total Dissolved Solids
b. Nutrients: Ammonium, Nitrite, Nitrate, Phosphate	**b. Nutrients**: Ammonium, Nitrite, Nitrate, Phosphate	**b. Nutrients**: Ammonium, Nitrite, Nitrate, Phosphate
c. Demand Parameters: DO, BOD,COD	**c. Demand Parameters:** DO, BOD,COD	**c. Demand Parameters: --**
d. Major Ions: Ca, Mg, Na, K, HCO_3, CO_3, Cl, SO_4, F, Fe, Mn	**d. Major Ions**: Ca, Mg, Na, K, HCO_3, CO_3, Cl, SO_4, F, Fe, Mn	**d. Major Ions**: Ca, Mg, Na, K, HCO_3, CO_3, Cl, SO_4, F, Fe, Mn
Microbiological/Biological : Total Coliform, Fecal Coliform, Chlorophyll a, b, c,Plankton Count	**Microbiological:** Total Coliform and Fecal Coliform	**Microbiological:** Total Coliform and Fecal Coliform

The physico-chemical analysis is performed as per Standard Methods for the Examination of Water and Wastewater (APHA, 2017; Jain and Bhatia, 1988). The details of analytical methods and equipment are given in **Table 8.2**. Ionic balance was calculated and the error in the ionic balance was within 5%.

The major cations and anions in the samples were analyzed with the help of Metrohm Ion Chromatograph. Ion chromatography uses ion exchange resins with different fuctional groups for separating the ions, based on ionic interactions, which are detected by conductivity detector. Quantification of cations and anions in the sample is based upon calibration curve of standard solutions of respective cations-anions.

Perkin-Elmer Inductively Coupled Plasma Mass Spectrometer (ICP-MS) was used for analysis of trace metals. The operational conditions were adjusted in accordance with the manufacture's guidelines to yield optimal determination. The calibration curve of mixed trace metal solution of 10, 50, and 100 ppb were prepared and with the help of same the concentration of metals in the samples were quantified. These calibration curves were determined several times during the period of analysis. The samples were digested in nitric acid and hydrogen peroxide for removal of organics in Anton Paar Multiwave PRO Microwave Reaction System and filtered through 0.45-micron filter paper before injecting in ICP-MS.

Table 8.2: Analytical Methods and Equipment used in the Study

S. N.	Parameter	Method	Equipment Used
A.	**Physical**		
	pH	Electrometric	pH meter
	Electrical Conductivity	Electrometric	Conductivity meter
	Total Dissolved Solids	Gravimetric Method	
	Total SuspendedSolids	Gravimetric	
	Turbidity	Nephelometric	Nephelometer
B.	**Major Cation and Anions**		
	Bicarbonate	Titration by H_2SO_4	Digital Burette
	Calcium	Conductivity Method	Ion Chromatograph
	Magnesium		
	Sodium		
	Potassium		
	Chloride		
	Fluoride		
	Nitrate		
	Ammonia		
	Sulfate		
	Phosphate		
C.	**Trace-Heavy Metals**	Digestion followed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS)	ICP-MS
D.	**Bacteriological**		
	Total Coliform	MPN	Colilert Bacteriological Kit
	E. Coliform		
D.	**Pollution Indicator**		
	COD	$K_2Cr_2O_7$ digestion	Redox Titration
	BOD	Respirometric	Oxitop BOD Analyzer
	DO	ModifiedWinklerazide	Iodometric Titration

The samples for bacteriological parameters were collected in sterilized bottles and were brought to laboratory in ice bath. The samples were processed for bacteriological determination with 24 hours of collection. The coliforms were determined by Most Probable Number (MPN) method by using Colilertkit.

The pollution status of ponds and influent to pond is determined by analyzing Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Dissolved Oxygen (DO). The samples were preserved as per standard methods for these parameters. BOD analysis was started within 12 hours of samplecollection.

Total station surveys were conducted for estimation of the quantity of water and sludge removed from the ponds. The impact of pond water on the groundwater level was monitored in the hand pumps located along the periphery of the pond.

8.2.2 Soil/Sludge Characterization

Represenattive pond bed soil, sludge and agricultural soil samples were collected from each village pond in polythene bags. These samples were analyzed in laboratory for different soil parameters like permeability, soil texture and bulk density following the standard methods.

To estimate the soil permeability, two types of methods were used i.e. constant head permeability method *(for coarse grained soil)* and falling head permeability method *(for finegrainedsoil)* in ICW Laboratory Permeameter apparatus.

Infiltration tests of pond beds were conducted to estimate the infiltration rate of pond bed soil. Tests were conducted using Double Ring Infiltrometer method *(having 30 cm diameter and 60 cm diameter rings)*. Pond bed soil samples, sludge samples, agricultural soil samples were collected and analyzed in Soil Water Laboratory of NIH. Nutrients in the soil samples were analyzed using PUSA kit. Total 12 parameters were analyzed in PUSA Soil Testing kit (Table 8.3).

Table 8.3: Parameters analyzed in PUSA Soil Testing Kit

S. No.	Parameter	Range
1	Organic Carbon	0-1.72%
2	Available Nitrogen	0-124.4mg/kg
3	Phosphorus	0-17.8 mg/kg
4	Potassium	0-88.9mg/kg
5	Zinc	0.5 -10 mg/kg
6	Iron	0.5 -50 mg/kg
7	Copper	0.1-10 mg/kg
8	Manganese	0.5 -20 mg/kg
9	Boron	0.1-2 mg/kg
10	Sulphur	1.0 – 150 mg/kg
11	Electrical Conductivity	0.4-1.6 mS/cm
12	pH	2 to 12

8.2.3 Assessment of Eutrophic Status

Eutrophication of ponds was assessed using Carlson's Trophic State Index (Carlson, 1977) and other relevant indices. The trophic status calculations require measurement of Secchi Disc, Nutrients, Plankton Density, Chlorophyll, etc**.**

8.2.4 Establishment of NTS Technology (Floating Wetland)

Pollutants reaching the pond through wastewater are removed through establishment of a floating wetland based natural treatment system. Floating wetlands (FW) are container gardens that float on surface of the water **(Figure 8.3),** which allow effective removal of nitrogen, phosphorous and heavy metals. Wastewater pollutants (major and minor pollutants) along with pathogens are removed by the plants and biofilm of plant roots as well as coconut coir. The removal takes place by plant uptake, nitrification, absorption, adsorption, filtration, biological degradation, breakdown etc. Atmospheric oxygen and photosynthetic oxygen comes in hollow stem of reed plant and goes through roots and pumped into wastewater, thereby increasing the dissolved oxygen of water. Floating wetland provides better habitat for aquatic flora and fauna. The cross-section of a pond showing wastewater treatment through Floating Wetland is shown in **Figure 8.4**. The plan view and construction of floating bed is shown in **Figure 8.5 and 8.6** respectively.

In order to decontaminate the domestic wastewater entering the pond of village from the components which are detrimental to pond ecosystem, Floating Wetland based treatment technology is proposed (Billore S.K. and Prashant S.J.K., 2008). The specific aquatic plants required for implementing this technology were developed in the Nursery established in the NIH campus.

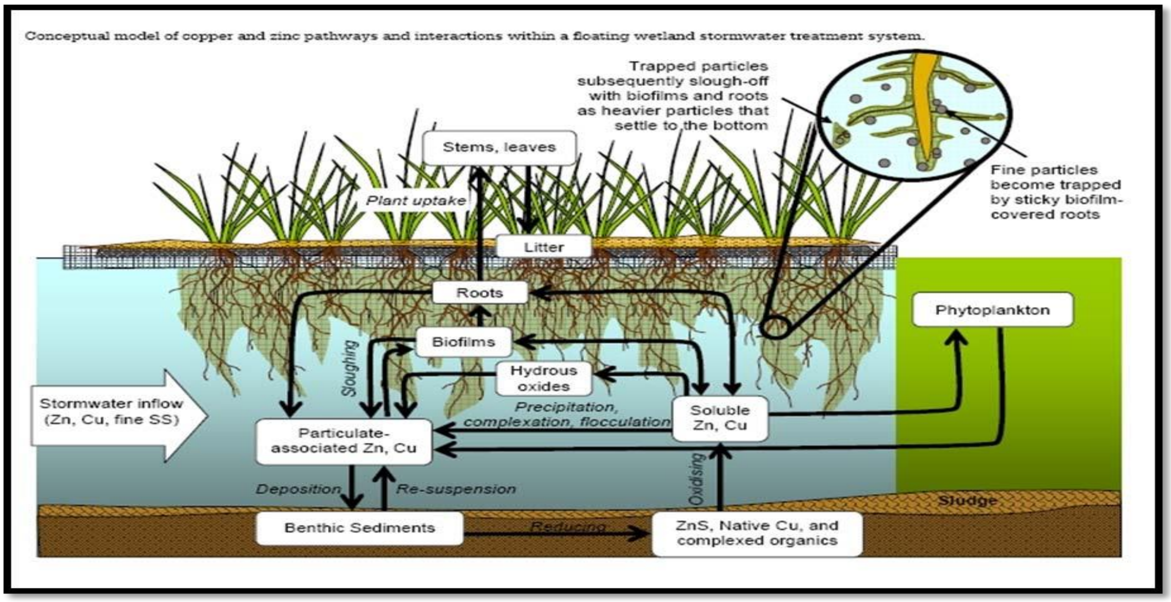


Figure 8.3: Concept of Floating Wetland

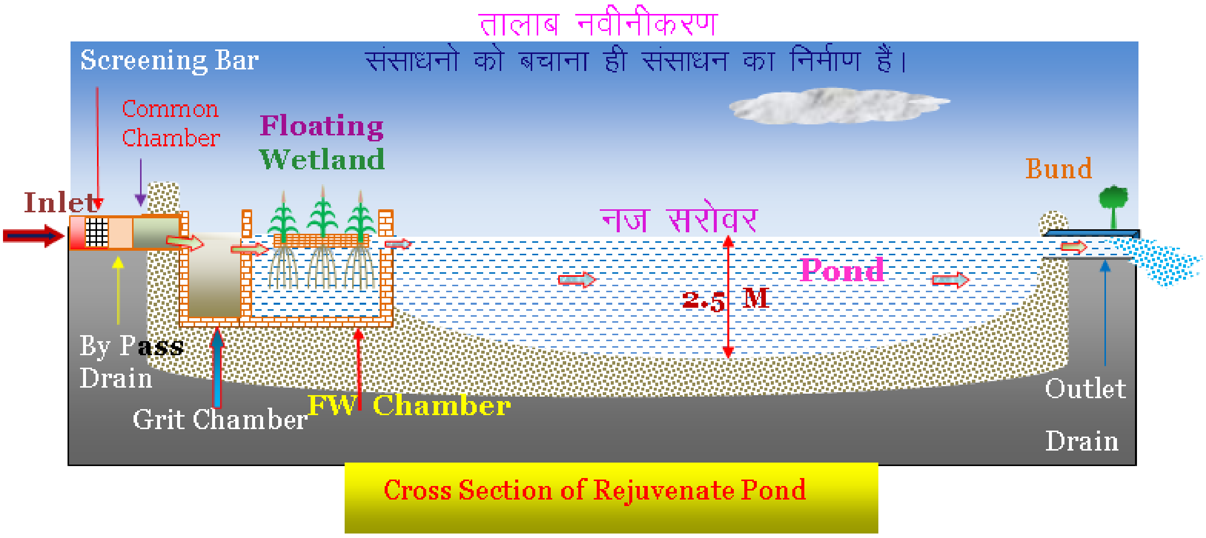


Figure 8.4: Cross- Section of Pond Showing Floating Wetland

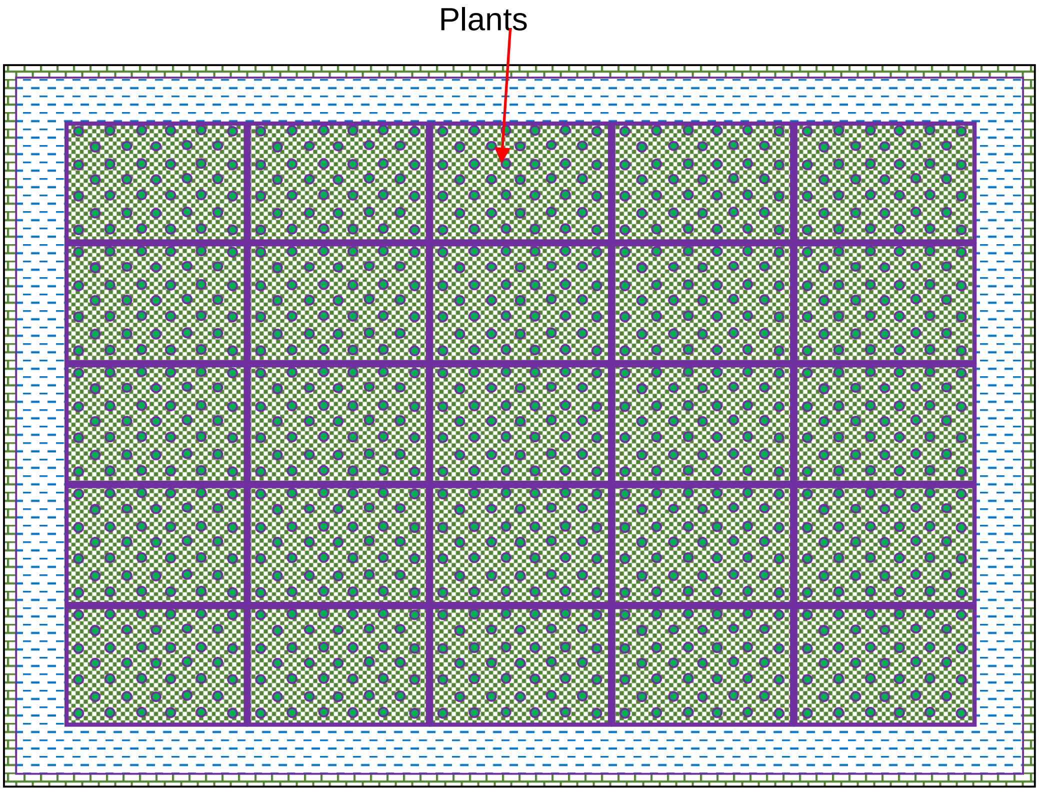


Figure 8.5: Design of Floating Bed (Area: 50 m^2; 25 floating beds)

Figure 8.6: Construction of Floating Bed (Area: 50 m^2; 25 floating beds)

8.2.5 Nursery Development for Floating Wetland

To supply the required plants for Floating Wetland to be used in wastewater treatment at identified sites, a nursery was developed at NIH (Figure 8.7). The following are the details of Nursery developed at NIH:

Nursery Area	=	180m^2
Total no. of Beds	=	14
No. of Plant	=	11000
Reeds Plant	=	9000
Cannas Plant	=	2000
Typha	=	300
Arundo	=	150
Bulrush	=	115

Mainly the plants developed at the nursery included Reeds, Canna Indica, Typha, Arundo and Bulrush. Plants identified for use in the floating wetland were selected based on the criteria:

1. Aquatic Plant should be an Emergent plant(able to grow on constructed floating platform).
2. Capable to Tolerance to high quality of Eutrophication (since it is the bio-machine to treat the water).
3. Must have Fibrous Root system (Maximum root surface area/rhizosphere of plant for bio film development.
4. Should be Perennial (round the year growth; especially during the summer when pollution concentration is more and plant growth is maximum to treat the pollution) & evergreen (Beautification of aquatic ecosystem).
5. Green vertical canopy should be good for enhancement of biodiversity (like shelter for birds and wildlife).
6. Some economic value (fodder value, fuel value and composting value) of aquatic plant.
7. Capacity to tolerate pond`s climate, strong wind current and heat wave during the extreme weather.
8. It should not be tree, spiny, small size and taproot
9. Locally available aquatic plants (indigenous species).Reed is specially recommended in the literature and CPCB guidelines (year 2003) for this type of application. Its stem is completely hollow and act as Oxygen pump [like aerator] to pump water through the roots and keep the environment around the roots aerobic supporting the microbes oxidizing the organics present in the water. Luckily this plant is growing throughout in India, adaptable to local climate.

8.3 Capacity Building & Mass Awareness

Mass awareness and capacity building activities were conducted during different stages of implementation of the project. The project started in consultation with the Heads of local Gram Panchayats (GP), who were briefed about the activities planned to be undertaken in the project. Through regular interactions, the GP were motivated to own the responsibility of maintaining the rejuvenated village ponds, and to manage the developed facilities for reuse of treated wastewater in the village for non-potable purposes. This also included preparation of SOPs for smooth operation of the treatment facilities at pond.

Figure 8.7: Nursery Development at NIH Roorkee

9.0 DATA COLLECTION AND ANALYSIS

9.1 Site Survey and Assessment

A detailed survey comprising estimation of wastewater discharge in the pond, approximate area and volume of the pond, number of households connected to the pond, *etc*. has been carried out for the 12 ponds selected for rejuvenation (Table 9.1).

Table 9.1. List of Village Ponds for Rejuvenation (As per BOQ)

S. N.	Name of Village & Pond	Pond Area (ha)	Perimeter (m)	Depth (m)	Capacity (m^3)	Catchment Area (m^2)
1.	Bhora Kalan (Block Sahpur, Dist.Muzaffarnagar)	0.85	373.15	4	23,710	463,727
2.	Bhora Khurd Pond-1 (Block Sahpur, Dist. Muzaffarnagar)	0.94	387.57	3.5	15,787	474,836
3.	Mohammadpur Madan Pond - 2 (Block Baghara, Dist. Muzaffarnagar)	0.29	306.75	3.5	9,536	289,777
4.	Biral (Block Budhana, Dist. Muzaffarnagar)	1.85	903.38	3.5	80,208	616,818
5.	Pavli Khas (Block Daurala, Dist. Meerut)	1.06	451.98	3.5	30,655	924,785
6.	Itawa Pond-2 (Block Budhana, Dist. Muzaffarnagar)	0.36	336.83	3.5	17,830	337,895
7.	Bhora Khurd Pond-2 (BlockSahpur, Dist. Muzaffarnagar)	0.79	371.15	3.5	37036	540128
8.	Siwaya Jamalullapur (Block Daurala, Dist. Meerut)	0.74	451.98	3.5	17,242	325,030
9.	Roni Hazipur (Block Charthawal, Dist. Muzaffarnagar)	0.68	343.48	3.5	20,736	540,128
10.	Antwara (Block Khatauli, Dist. Muzaffarnagar)	0.35	222	3.5	6,062	335,336
11.	Munnawarpur Kalan (Block Khatauli, Dist. Muzaffarnagar)	0.27	205.87	3.5	10,727	324,648
12.	Itawa Pond-1 (Block Budhana, Dist. Muzaffarnagar)	0.69	484.66	3.5	10,065	159,207

9.2 Water Quality Sampling and Analysis:

Water samples were collected from ponds, inlet to ponds and nearby handpumps for water quality characterization during May 2017 to July 2017 (Before rejuvenation), April and May 2019 and January 2020 (After rejuvenation) (Table 9.2). The samples were analyzed for the physcio-chemical, microbial, trace metals, and other pollution indicating parameters.

Table 9.2: List of Water Samples Collected in the Year 2017, 2019 & 2020

Name ofVillage	Village ID	No. of Ponds	No. of Samples (Year 2017)	No. of Samples (Year 2019)	No. Of Samples (Year 2020)
Munnawarpur Kalan	MK	1	04	06	03
Antwara	AT	1	04	05	03
SiwayaJamalullapur	SW	1	05	02	03
Pavli Khas	PK	1	04	03	03
Roni Hazipur	RZP	1	04	03	03
MohammadpurMadan	MM	1	06	03	-
Bhora Kalan	BKL	1	04	03	03
Bhora Khurd	BK	2	07	03	05
Biral	BR	1	04	03	03
Itawa	IT	2	06	02	-
Total		**12**	**48**	**33**	**26**

9.3 Collection and Analysis of Soil/Sludge Samples

Pond soil, sludge samples and agricultural soils from the village ponds were collected and analyzed in NIH, Roorkee/ ICAR-CSSRI Karnal. Infiltration test were conducted to measure the infiltration rate in pond bed at identified village ponds of western UP, India. Detail of samples collected is given below Table 9.3

Table 9.3: List of Field Investigations done in the Year 2018 & 2019

S. No	Village Name		Field Investigations/R&D WORK						
			Sludge Sample	Soil Sample		Infiltration Test	GW Level Measurement	GW Sample	Agri. soil sample
				Disturbed	Undisturbed				
A	MUZAFFARNAGAR								
1	Mohammadpur Madan - 2	Baghra	23/04/19	Waterin pond	Waterin pond	Waterin pond	23/04/19	23/04/19	23/4/19
2	Bhora Kalan	Shahpur	17/10/18	17/10/18	17/10/18	4/12/18	4/12/18	4/12/18	17/10/18
3	Bhora khurd-1	Shahpur	11/01/19	11/01/19	25/04/19	25/04/19	25/04/19	25/04/19	11/01/19
4	Bhora khurd-2	Shahpur	11/01/19	11/01/19	11/01/19	11/01/19	-	-	11/01/19
5	Itawa-1	Budhana	9/01/19	9/01/19	9/01/19	9/01/19	24/05/19	24/05/19	9/01/19
6	Itawa-2	Budhana	8/01/19	8/01/19	8/01/19	8/01/19	24/05/19	24/05/19	8/01/19
7	Biral	Budhana	3/01/19	3/01/19	3/01/19	3/01/19	22/05/19	22/05/19	3/01/19
8	Munnawarpur Kalan	khatauli	17/10/18	17/10/18	17/10/18	17/10/18	15/05/19	15/05/19	17/10/18
9	Roni Hazipur	Charthawal	24/04/19	24/04/19	24/04/19	24/04/19	24/04/19	24/04/19	24/04/19
10	Antwara	Khatauli	7/01/19	7/01/19	7/01/19	7/01/19	15/05/19	15/05/19	7/01/19
B	Meerut								
1	Siwaya	Shiwaya	15/10/18	15/10/18	15/10/18	15/10/18	23/05/19	23/05/19	23/05/19
2	Pavli khas	Pavlikhas	18/03/19	18/03/19	18/03/19	18/03/19	24/05/19	24/05/19	18/03/19

Table 9.4: Groundwater level in identified villages (Year 2017 & 2019)

	Location of Hand Pump	GW Depth (BGL in m), June 2017	GW Depth (BGL in m) May-June (2019)
Munnawarpur	Outside of village (0.5Km before Village)	9.7	9.99
	Entrance of village/Near Pond	7.94	8.33
	Middle of village (300m away from pond)	7.4	-
	Middle of village	8.04	8.84
	Middle of village	7.96	-
	Exit side (900m away from pond)	8.09	-
Antawara	Entrance of village/Near Pond	4.36	6.79
	Middle of village (I)	6.18	7.02
	Middle of village (II)	7.94	3.81
	Exit side	3.87	4.75
Shiwaya	Entrance of village/Near Pond	12.5	13.53
	Pond/Near Pond	11.51	-
	Middle of village	-	11.7
Pavli Khas	Entrance of village/Near Pond	13.51	14.13
	Pond/Near Pond	12.86	13.48
	Exit side/I km distance from pond	13.77	14.51
	Pond inlet/Wastewater	13.09	-
Roni Hazipur	Entrance of village/Near Pond	13.21	13.04
	Middle of village (I)	13.03	12.22
	Middle of village (II)	13.88	13.2
	Pond/Near Pond	10.82	-
	Near Pond 20 m distance	14.42	-
Mohamadpur Madan	Near Pond 2 HP	21.63	21.36
	Pond 1 Hand pump	21.2	20.79
	Middle of village	-	20.85
Bhaura Khurd	Entrance of village	29.43	25.78
	HP Near pond1	28.31	25.94
	Hand pump near Pond 2	27.75	26.36
	Middle of village (1)	28.89	-
	Middle of village (2)	27.62	-
Bhaura Kalan	Entrance of village HP	37.49	26.16
	Submersible Near pond	38	25.86
	Middle of village	-	25.25
Itawa	Entrance of village HP/Hp away from pond1	33.64	29.7
	HP Near pond1	33.13	31
Biral	Entrance of village HP	37.27	33.52
	HP Near pond	33.7	33.8
	Middle of village	-	34.2

9.4 Civil Work Component of Pond Rejuvenation (through NPCC Ltd.)

As per MoU with NPCC, the following civil works were allotted to NPCC Ltd. for rejuvenation of identified ponds:

1. Dewatering
2. De-sludging
3. Peripherydrain
4. Animalramp
5. Construction of inlet chamber & sedimentationtank
6. Fabrication of floating wetland (with identified aquatic plants grown in Nursery atNIHRoorkee)

The progress of the civil work was regularly monitored by NIH through field survey as well as progress review meetings. On 4/1/2019, the Project Manager and Engineers ofNPCC Ltd. informed that the local villagers are objecting to the construction of periphery drain around the ponds. Moreover, Director (R&D), Ministry of Jal Shakti asked to reduce the budget especially the cost related to civil works. In light of above, during the meeting held on 04.01.2019 at NIH, Roorkee with NPCC Ltd., following decisions were taken-

1. The periphery drain should be removed in all ponds, except in one pond located at Munnawarpur Kalan as the work was already completed**.** However, reduced periphery drain work may be carried out in limited number of ponds as pilot project where Floating Wetland is to beestablished, if possible.
2. Animal Ramp to be removed in all ponds. The ramp for desilting work will be left as it is for this purpose.
3. Major inlet works (common pit, screen chamber, grit chamber & Floating Wetland) to be done on only one selected major drain in 03 identified ponds (i.e., Munnawarpur kalan, Pavli khas & Antwara) as a pilot project.
4. Due to Constraints of fund as informed by Director R&D, only one pond at Munnawarpur kalan was considered for installation of all the proposed units.

Further, after the second visit of Director, R&D (MoWR, RD&GR), during 2-3 April, 2019, the major inlet works (common pit, screen chamber/bar, grit chamber & Floating Wetland) were replaced by minor inlet works (common pit, screen chamber/bar) in all identified inlets of remaining 11 ponds (except Munnawarpur Kalan, Dist. Muzaffarnagar). Due to non-availability of land by the Gram Panchayat (as reported by the NPCC), it was also dropped.

In view of the above, the status of the revised scope of work is shown in Table 9.5 and the cost summary of civil works (as per NPCC) for each pond is given in Table 9.6

Table 9.5: Status of the Revised Scope of Work

<table>
<tr><th rowspan="2">S.No</th><th rowspan="2" colspan="2">Village name</th><th colspan="7">PROGRESS OF REVISED WORK</th></tr>
<tr><th>Dewatering</th><th>Removal of sludge</th><th>Screening bar inlet</th><th>Sedimentation Tank</th><th>Periphery Drain Work</th><th>Floating Wetland</th><th>Compaction of pond periphery</th></tr>
<tr><td>A</td><td colspan="9">MUZAFFARNAGAR</td></tr>
<tr><td>1</td><td>Mohammadpur Madan - 2</td><td>Baghra</td><td>Completed</td><td>Completed</td><td rowspan="7" colspan="4">Dropped</td><td>Completed</td></tr>
<tr><td>2</td><td>Bhora Kalan</td><td>Shahpur</td><td>Completed</td><td>Completed</td><td>Completed</td></tr>
<tr><td>3</td><td>Bhora khurd-1</td><td>Shahpur</td><td>Completed</td><td>Completed</td><td>Completed</td></tr>
<tr><td>4</td><td>Bhora khurd-2</td><td>Shahpur</td><td>Completed</td><td>Completed</td><td>Completed</td></tr>
<tr><td>5</td><td>Itawa-1</td><td>Budhana</td><td>Completed</td><td>Completed</td><td>Completed</td></tr>
<tr><td>6</td><td>Itawa-2</td><td>Budhana</td><td>Completed</td><td>Completed</td><td>Completed</td></tr>
<tr><td>7</td><td>Biral</td><td>Budhana</td><td>Completed</td><td>Completed</td><td>Completed</td></tr>
<tr><td>8</td><td>Munnawarpur Kalan</td><td>Khatauli</td><td>Completed</td><td>Completed</td><td>Completed</td><td>Completed</td><td>Completed</td><td>Completed</td><td>Completed</td></tr>
<tr><td>9</td><td>Roni Hazipur</td><td>Charthawal</td><td>Completed</td><td>Completed</td><td rowspan="2" colspan="4">Dropped</td><td>Completed</td></tr>
<tr><td>10</td><td>Antwara</td><td>Khatauli</td><td>Completed</td><td>Completed</td><td>Completed</td></tr>
<tr><td>B</td><td colspan="9">MEERUT</td></tr>
<tr><td>1</td><td>Siwaya</td><td>Shiwaya</td><td>Completed</td><td>Completed</td><td>Dropped</td><td rowspan="2" colspan="3">Dropped</td><td>Completed</td></tr>
<tr><td>2</td><td>Pavli khas</td><td>Pavlikhas</td><td>Completed</td><td>Completed</td><td>Completed</td><td>Completed</td></tr>
</table>

Table.9.6: Cost summary for rejuvenation of ponds

S.N.	Ponds/Village	Estimated cost (Rs.)	Actual Cost (Rs.)
1	Bhora Kalan (Khasra no. 168), Dist. Muzaffarnagar	74,81,599	68,46.884
2	Bhora Khurd Pond 1(Khasra no. 440), Dist.Muzaffarnagar	62,61,769	80,68,412
3	Mohmadpur Modan Pond 2 (Khasra no. 226), Dist.Muzaffarnagar	31,77,715	31,17,157
4	Biral (Khasra no. 640), Dist. Muzaffarnagar	1,04,04,740	41,55,393
5	Pavli Khas (Khasra no. 973/1), Dist. Meerut	78,81,421	70,14,798
6.	Itava Pond No. 02 (Near Masjid), Dist. Muzaffarnagar	53,21,661	48,00,429
7.	Bhora Khurd Pond No. 02 , Dist. Muzaffarnagar	54,88,544	59,50,269
8.	Siwaya Jamalullapur, Dist. Meerut	65,43,384	49,91,292
9.	Roni Hazipur, Dist. Muzaffarnagar	51,60,199	41,30,966
10.	Antwara, Dist. Muzaffarnagar	43,88,719	24,75,628
11.	Munnawarpur Kalan, Dist. Muzaffarnagar	32,83,913	32,72,682
12.	Itava Pond No. 01 (Bademandir wala), Dist.Muzaffarnagar	67,19,374	60,80,012
13	Total Amount (Rs.)	7,21,13,039	6,09,03,922
I	Contingency @3%	21,63,391	18,27,118
	Total Amount (Rs.)	7,42,76,431	6,27,31,040
II	Labour cess @1%	7,42,764	6,27,310
III	GST @12%	89,13,172	75,27,725
IV	PMC @ 7%	51,99,350	43,91,173
V	GST ON PMC @ 18%	9,35,883	7,90,411
Total Cost of Civil Work		**9,00,67,600**	**7,60,67,659**

9.5 LU/LC Mapping of Pond Surroundings for Water Reuse Planning

Wastewater can be recycled and reused for a variety of water demanding activities such as agriculture, firefighting, flushing of toilets, industrial cooling, park watering, formation of wetlands for wildlife habitats, etc. (Yang and Abbaspour, 2007). The D'Angelo report (1998) indicated that the acceptability of using recycled water in agriculture is higher for non-edible crops than for edible crops. For edible crops, the preference is for crops that must be peeled prior to human consumption, such as oranges and sweet corn. In temperate zones of Australia reclaimed water is being used to irrigate a variety of crops including sugarcane. Eucalyptus forestry also is a major reuse option followed in Australia, which provides timber for a number of purposes including pulp wood and fire wood (Vigneswaran and Sundaravadivel, 2004). It is necessary to prepare Land Use/ Land Cover maps of villages to identify various stakeholders based on their land use patterns like crop lands, orchard/ groves, barren lands/ brick making factories, settlements etc. for reuse of recycled/ treated or semi-treated wastewater collected in the ponds after rejuvenation.

It is a wise decision that, the disposal of treated wastewater is at its point of origin rather than transporting it to a longer distance. As the storage capacity of ponds after rejuvenation ranges from around 9,000 m^3 to 45,000 m^3, to limit the cost of transportation of treated wastewater, 1 Km of distance is fixed for every pond which caters the suitable land use pattern having sufficient area. Land Use/ Land Cover maps of villages were prepared using ArcMap 10 software. The ponds under the study were digitized as polygon features by adding online satellite image (google earth images: Feb – May 2018) to ArcMap – ArcInfo window as a base map. The centroid of each polygon was calculated and a circle of 1 Km radius around it was drawn using geoprocessing tools like buffer. Then all land use patterns like crop lands, orchard/groves, barren lands/brick making factories, settlements etc. were digitized using editor tool. Also, all obstructions like canals, river/streams, railways, highway roads, etc. were digitized to know the difficulties in transporting the treated wastewater for reuse. Then combined all similar land use patterns using merge tool of editor. Clipped the polygon file using concentric circles of various radii like 100m, 200m, 300m, 400m and 500m to calculate area under various land use patterns at specified distances (Figure 9.1 and Annexure-II).

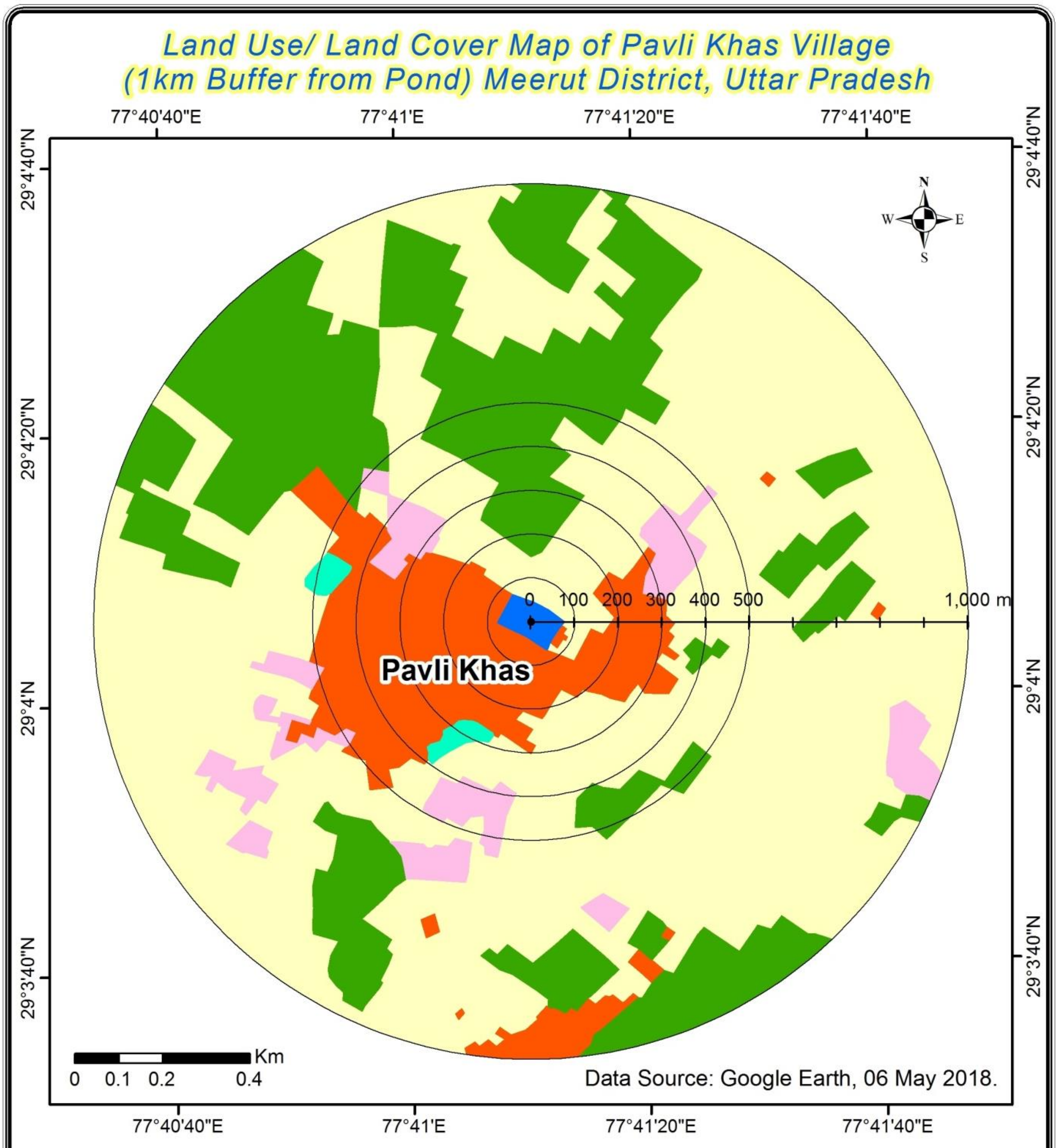
The treated or semi-treated wastewater collected in rejuventated ponds of villages under this project can be used to irrigate crop land, orchard/grove, barren land, etc. as given in table.9.7. The advantage of using treated domestic wastewater is the presence of the nutrients in the water which reduces the demand of fertilizer for the crops.

Table.9.7: Rejuvenated Pond water Resuse Planning upto a Distane of 500 m

S. No.	Village Pond	Crop Land (Ha)	Orchard/Grove (Ha)	Barren Land-Fodder (Ha)
1	Pavli Khas	35.22	9.74	5.84
2	Antwara	54.15	0.36	--
3	Bhora Khurd – 1*	52.89	--	0.18
4	Bhora Khurd – 2*	54.86	--	--
5	Bhoura Kalan	33.98	8.24	0.30
6	Biral	43.83	--	1.23
7	Itawa – 1#	48.75	--	--
8	Itawa – 2#	47.98	--	0.57

9	Mohammadpur Madan	51.97	1.26	0.82
10	Munnawarpur Kalan	67.26	8.62	1.32
11	Roni Hazipur	33.08	0.68	--
12	Siwaya	35.40	--	8.59

(*,# village ponds represents common LULC area within radius of 500m)



S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land	12.90	5.84	3.32	0.29	0.00	0.00
2	Crop Land	194.23	35.22	21.00	9.81	4.37	0.97
3	Orchard/ Grove	74.07	9.74	4.20	2.12	0.32	0.00
4	Settlement	30.63	25.55	20.05	14.76	6.85	1.15
5	Water Body (Other Ponds)	1.28	1.16	0.66	0.28	0.00	0.00
6	Water Body (Pond under Study)	1.02	1.02	1.02	1.02	1.02	1.02

Figure 9.1: Land Use/ Land Cover Map of Pavli Khas Village

10.0 RESULTS & DISCUSSION

10.1. Wastewater Treatment Facility

Initially the project envisaged installation of floating wetland technology for the treatment of wastewater entering into the ponds from village catchment. Construction of a sedimentation tank was considered a prerequisite for the installation of floating wetlands. However, due to high cost estimate submitted by the NPCC, the construction of sedimentation tank and other related civil works were discarded at eleven out of twelve pond sites after the visit of the Director (R&D) in April 2019**.** At the Munnawarpur Kalan village pond site, floating wetland treatment system was installed, and was found to be working satisfactorily when the NIH and NPCC team visited the site on 27 November 2019.

Inlet chambers were planned to be constructed at all pond sites for filtering of solid waste at pond inlets. At ten out of twelve sites, NPCC could not construct inlet chambers due to non-availability of land from the local GPs. At Munnawarpur Kalan and Pavli Khas village pond sites, these chambers were constructed (Figure 10.1) and are found working satisfactorily in filtering the incoming solid waste.Inlet channels in all ponds were cleaned and maintained for uninterrupted passage of incoming wastewater.

Complete view of Munawwarpur Kalan pond

Floating Wetlands in Munawwarpur Kalan pond

Inlet chamber in Pavli Khas pond

Rejuvenated pond in Antwara village

Figure 10.1. Sedimentation tank and Inlet chamber at Munnawarpur Kalan and Pavli Khas village pond sites

10.1.1 Storage Capacity of Ponds

De-weeding, de-watering and de-sludging were carried out in all ponds. After des-sludging, embankments were compacted with the available soil. Based on the Total Station Survey before and after de-sludging, the volume of de-sludging and storage capacity was estimated (Table 10.1).

Table 10.1: Storage Capacity of ponds after rejuvenation

S. No	Village Name		De-watering			De-sludging		Storage Capacity After Rejuvenation (m3)
			Depth (m)	Area (m2)	Volume of Water (m3)	Depth (m), sludge	Volume of Sludge (m3)	
PROJECT -1								
A	MUZAFFARNAGAR							
1	Mohammadpur Madan - 2	Baghra	0.94	3483	3,274	3.93	10207	13,481
2	Bhora Kalan	Shahpur	1.59	7098	11,286	4.46	23472	34,759
3	Bhora khurd-1	Shahpur	1.72	9514	16,364	4.12	29501	45,865
4	Bhora khurd-2	Shahpur	1.72	6873	11,822	4.58	23586	35,408
5	Itawa-1*	Budhana	1.01	5312	5,365	3.94	18903	24,268
6	Itawa-2*	Budhana	0.56	3960	2,218	5.33	18304	20,522
7	Biral	Budhana	0.93	14734	13,703	1.52	19815	33,518
8	Munnawarpur Kalan	khatauli	1.61	2379	3,830	2.71	6274	10,104
9	Roni Hazipur*	Charthawal	0.19	4952	941	3.3	16346	17,286
10	Antwara	Khatauli	0.55	2761	1,519	3.2	7554	9,072
B	MEERUT							
1	Siwaya	Shiwaya	1	7421.64	7,422	3.1	19397	26,819
2	Pavli khas	Pavlikhas	1.3	7316.64	9,512	4.16	22976	32,488

*Reaffirmed from NPCC survey sheet (bench mark=100m at bank top of pond)

Almost all ponds at the time of initiating the project were heavily infested with weeds and were almost completely filled with sludge. As a result, frequent flooding and water logging conditions prevailed at these sites. Deweeding and desludging has not only enhanced the storage capacity but also led to improving the pond water quality. Local villagers have confirmed this aspect and appreciated the project for this achievement. The storage capacity of ponds after rejuvenation is shown in the last column of the above table, which is considerably higher than the capacity available before the rejuvenation (shown in the column ‘Volume of water’).

10.2 Physico-chemical Analysis of Water Samples

10.2.1 Pondwater & Ground Water Samples (2017)

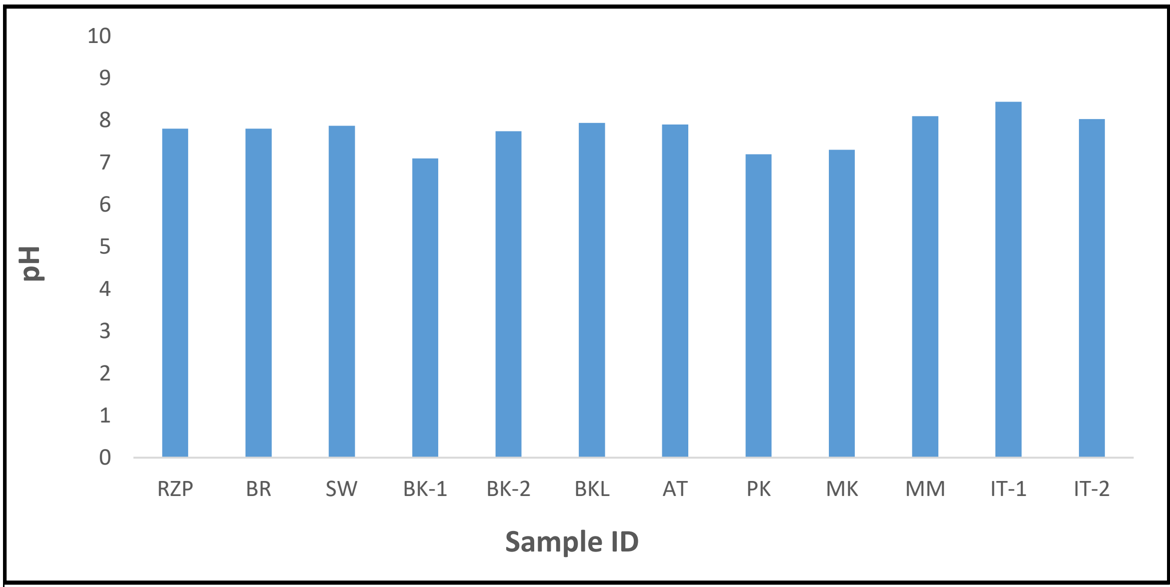
The water samples were analyzed for pH, Electrical Conductivity (EC), and Oxidation-Reduction Potential (ORP) immediately after sampling in the field, and for other parameters the samples were preserved and analyzed as per standard methods in the laboratory.

pH is one of the most important parameter in water chemistry and is defined as the negative of the base 10 logarithm of the molar concentration of hydrogen ion, and is measured as intensity of acidity or alkalinity on a scale ranging from 0-14. In natural waters, pH is governed by the equilibrium between carbon dioxide, bicarbonate and carbonates ions and in general, ranges between pH 4.5 to 8.5. Although pH has no direct impact on the health of consumers, it is one of the most important operational water quality parameter. BIS (2012) have prescribed pH value in the range of 6.5 to 8.5 for water used for drinking purpose. Moreover, the pH value prescribed vide the effluent standards notified vide G.S.R. 422(E) dated 19.05.1993 under Environment (Protection) Act, 1986 for discharge of effluents into inland surface water is 5.5 to 9.0. The pH of the analyzed water samples of study area varies from 6.7 to7.3.

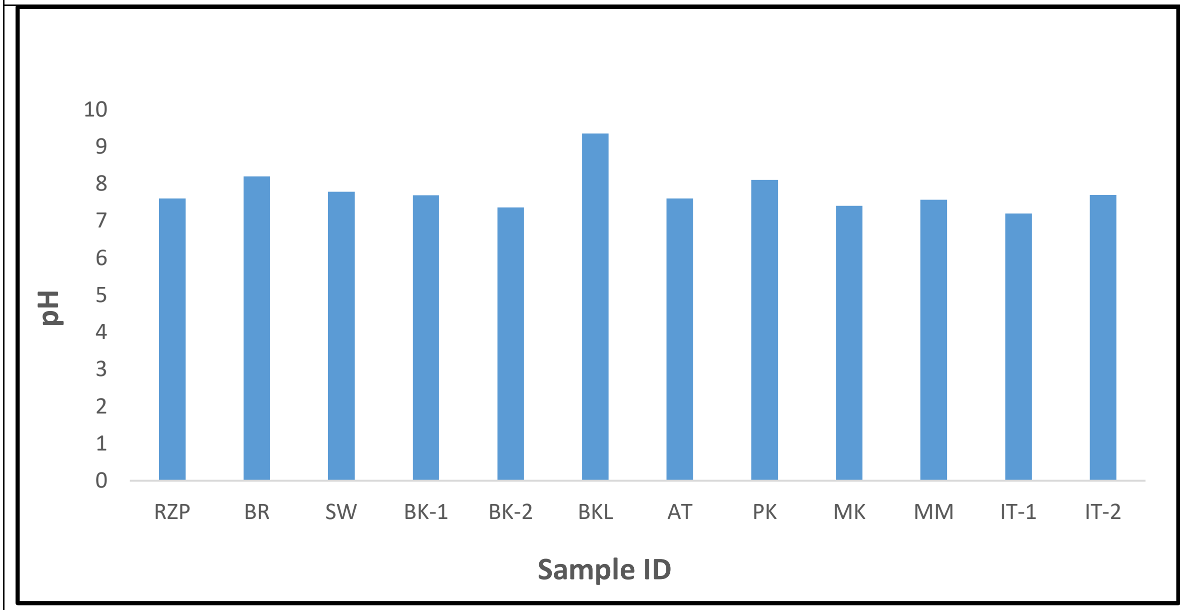
Electrical conductivity (EC) is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions; on their total concentration, mobility, and valence; and on the temperature of measurement. The electrical conductivity and dissolved salt concentrations are directly related to the concentration of ionized substance in water and may also be related to problems of excessive hardness and-or other mineral contamination. The overall range of the electrical conductivity varied between 570 µS/cm and 2050 µS/cm in the water samples

ORP is typically measured to determine the oxidizing or reducing potential of a water sample. It indicates the ability of the water body to self cleanse itself by breaking down the contaminants present in the water. Positive ORP value indicates the presence of higher oxidizing agent and negative ORP indicates reducing nature of the substance. Negative value of ORP in ponds indicates the anaerobic condition in ponds. ORP of distilled water and uncontaminated groundwater is ≈250 mV. ORP of pond water samples observed to be 55.6 to -220 mV. The ORP of most of the pondwater samples were negative indicative reducing environment and contamination of water with organics. Negative ORP is also an indicator of presence of anaerobic microbes in the water. The ORP of few groundwater samples were also negative and are capable of reducing the trace metals present in the aquifer minerals.

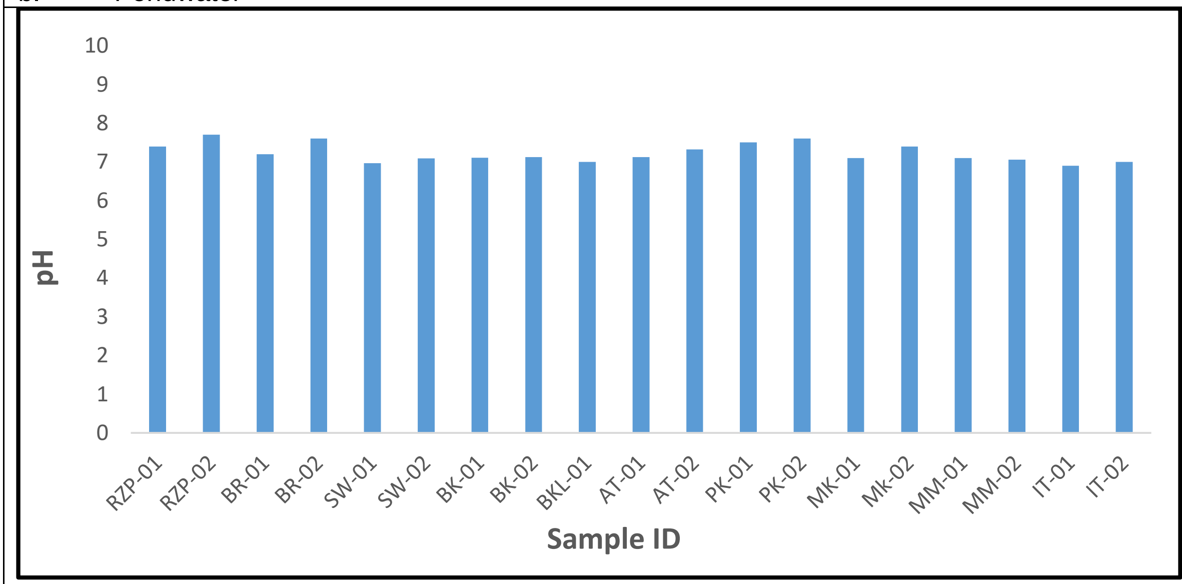
The results of in-situ analyzed parameters are presented below [Figure 10.2 (pH), 10.3 (EC) & 10.4 (ORP)].



a. Wastewater

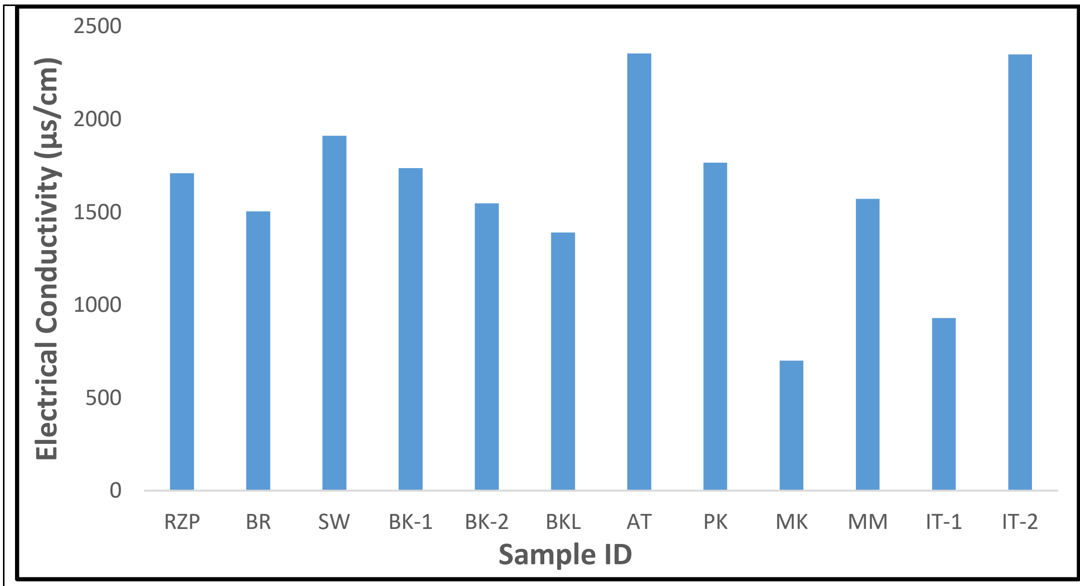


b. Pondwater

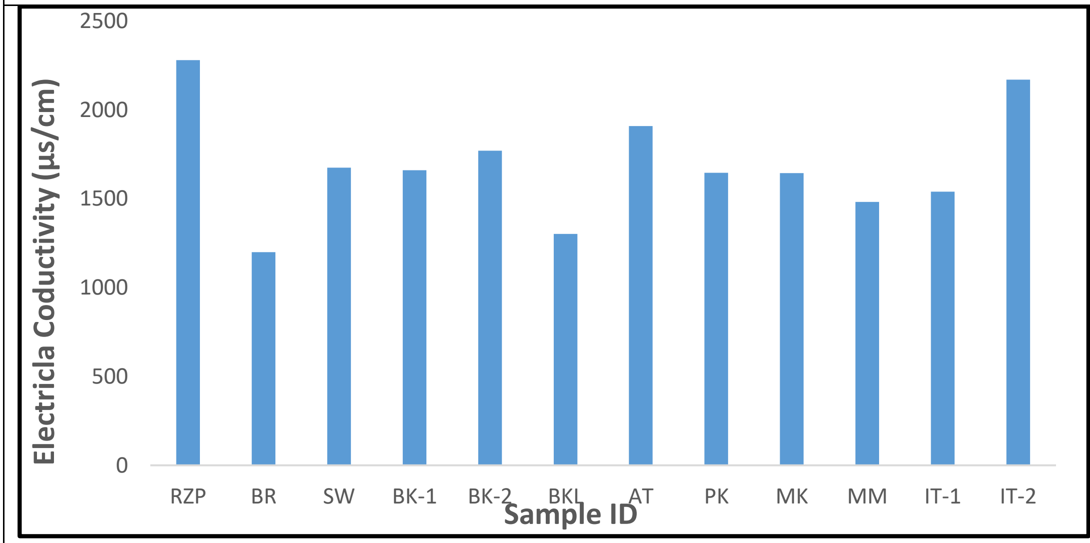


c. Groundwater

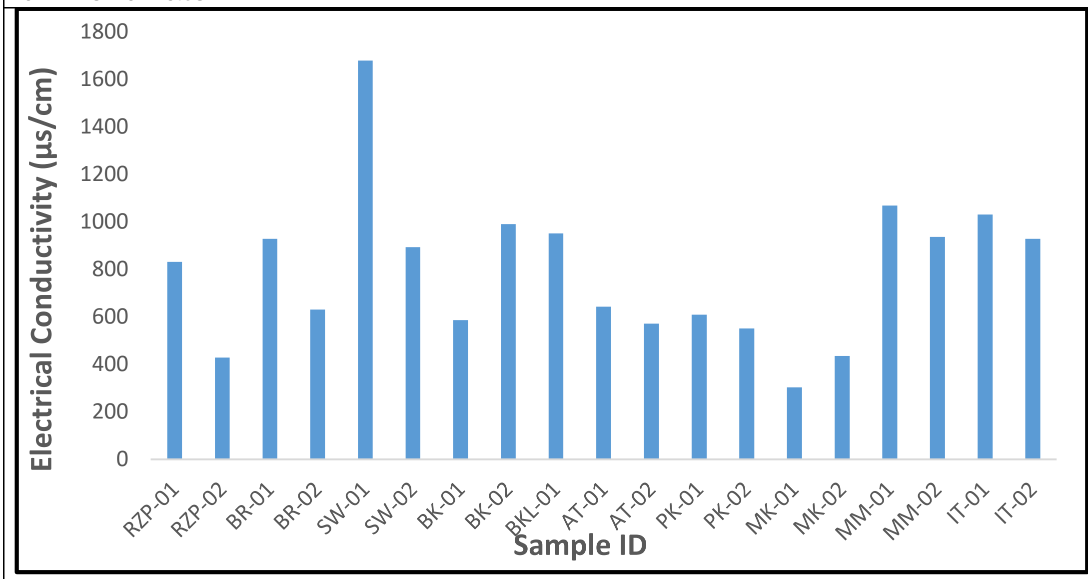
Figure 10.2. pH of Pondwater, Wastewater and Groundwater (2017)



a. Wastewater

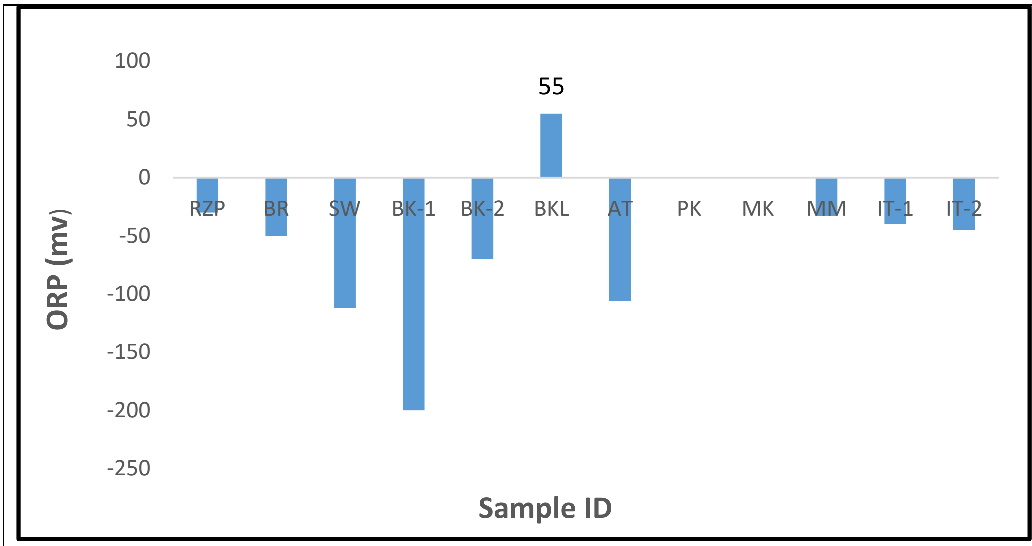


b. Pondwater

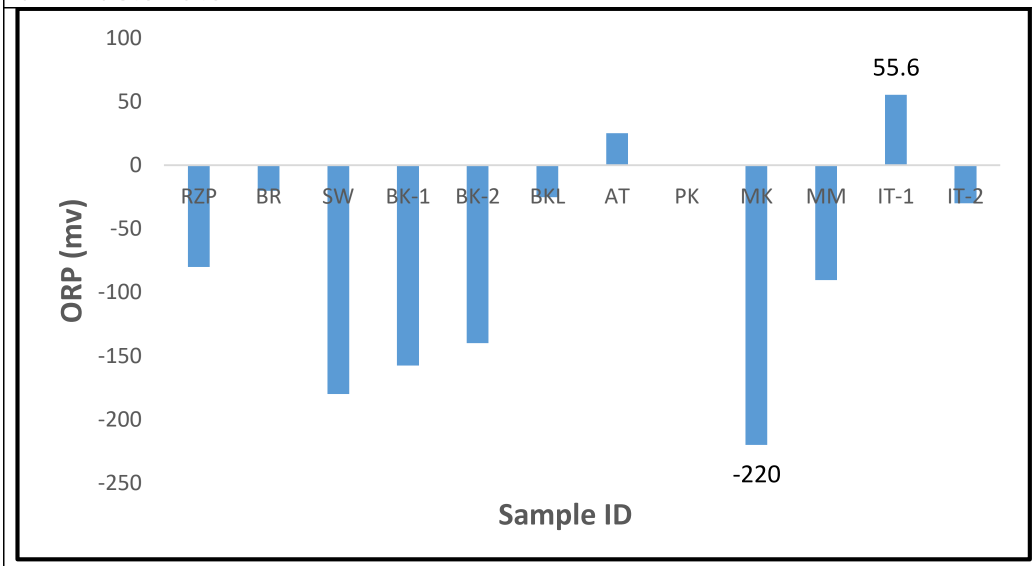


c. Groundwater

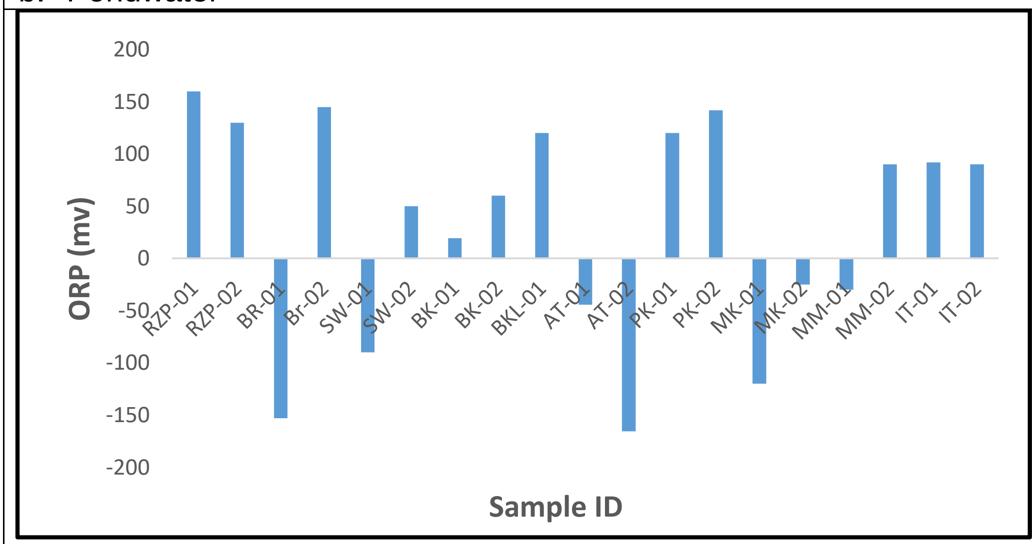
Figure 10.3. EC of Pondwater, Wastewater and Groundwater (2017)



a. Wastewater



b. Pondwater



c. Groundwater

Figure 10.4. ORP of Pondwater, Wastewater and Groundwater (2017)

The results of laboratory analysis of groundwater samples collected from the pond sites before rejuvenation (2017) are presented below (Figure 10.5 and Figure 10.6).

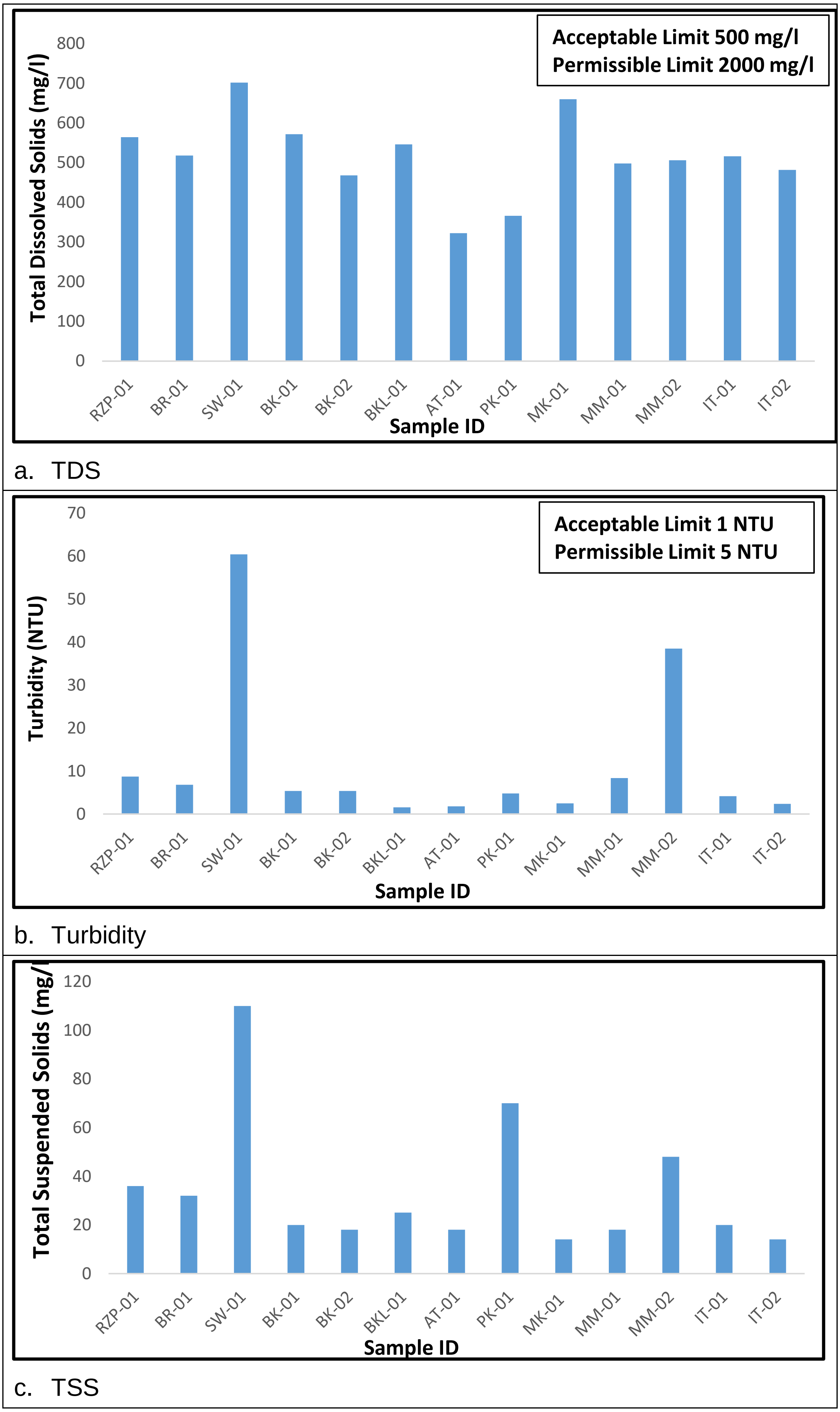
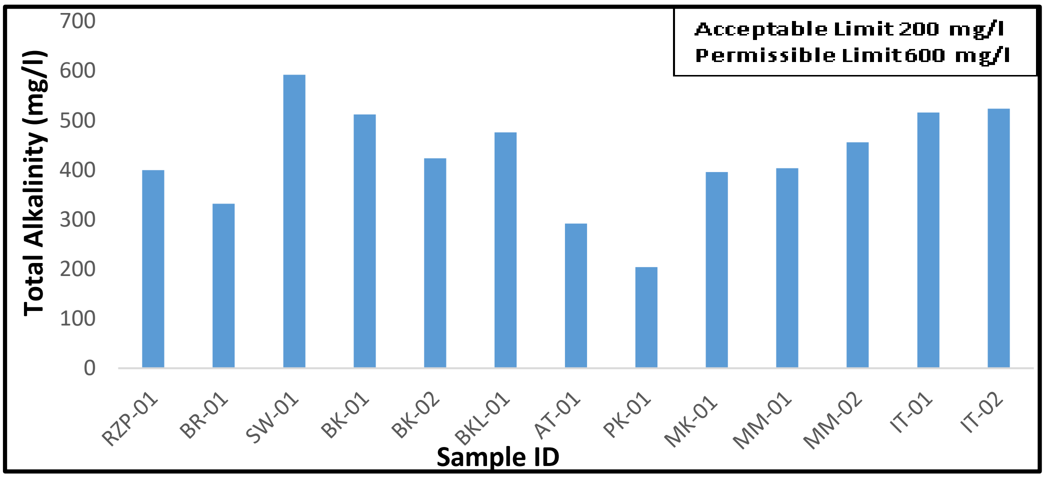
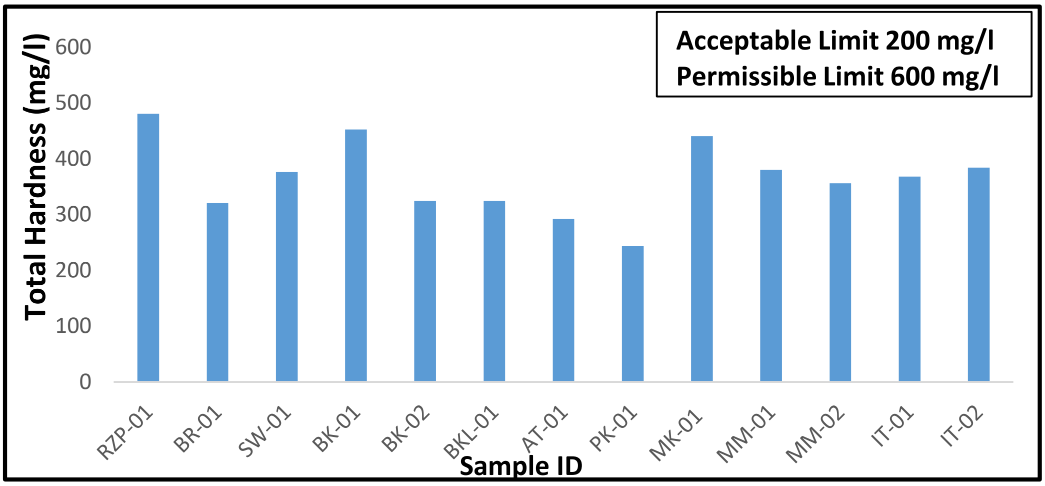


Figure 10.5: TDS, Turbidity and TSSin Groundwater Samples (2017)



a. Alkalinity



b. Hardness

Figure 10.6: Alkalinity & hardness in ground water samples (2017)

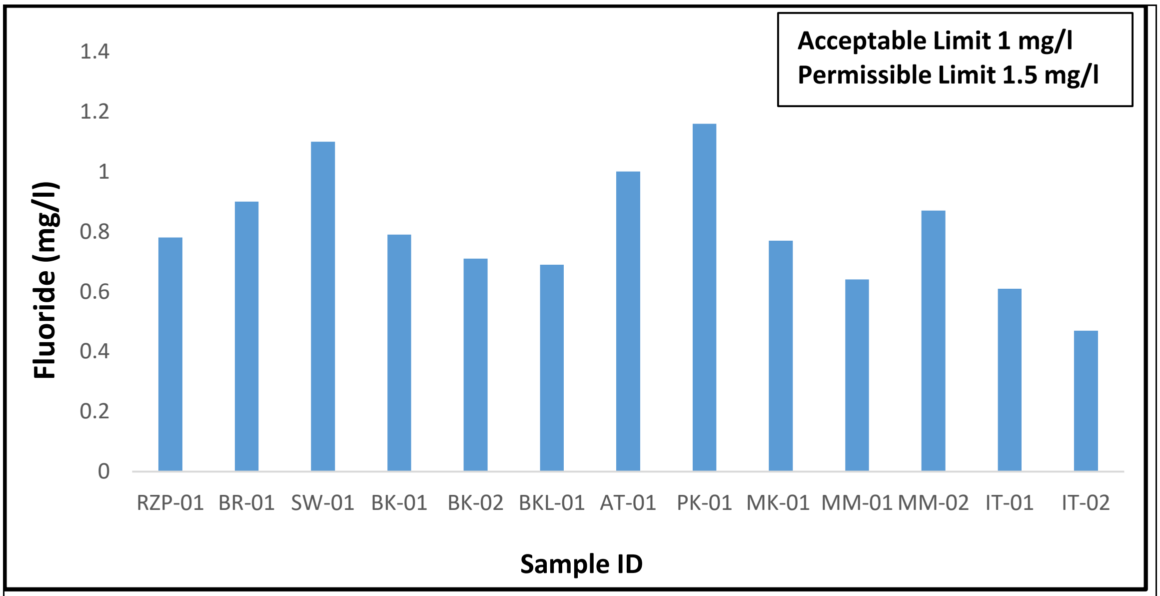
Total dissolved solids in water sample indicated the sum of ions and soluble non-ionic species present in the water. TDS of the groundwater samples were in the range of 322 to 660 mg/l. Around 61% samples exceeed the acceptable limit for drinking water prescribed by BIS (2012) and all the samples were well within the permissible limit for TDS.

Turbidity of the collected samples were in the range of 1.5 to 60.4 NTU. All the samples exceeded the acceptable limit and 60% of the samples exceeded the maximum permissible limit. The water samples turned yellow after some time indicating presence of iron in the samples which was further affirmed with the analysis of iron in the samples collected in 2019, which was exhorbitantly high, and in turn resulting in high turbidity of water. High iron in the water samples were because of lower ORP. The suspended solids in the analyzed samples were in the range of 14 to 110 mg/l again because of the iron precipitates.

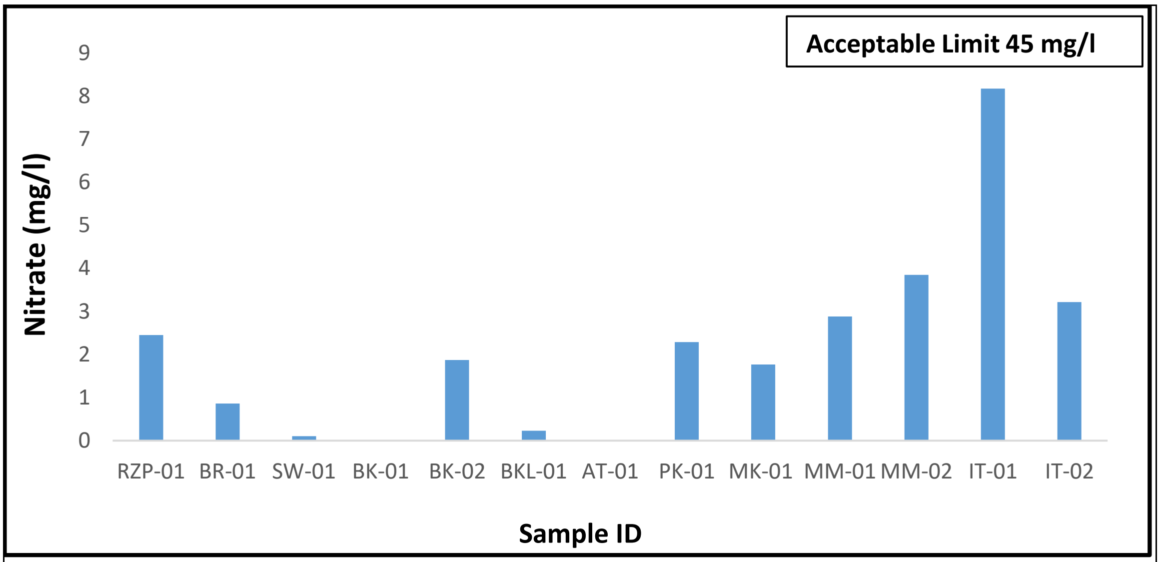
Total alkalinity and total hardness in the samples were in the observed to be 204-592 mg/l and 292 to 480 mg/l. Most of the hardness was observed to be temporary hardness, which will result in precipitates and scel formation in the utensils and plumbing. The hardness and alkalinity values were observed to be higher than the acceptable limit and lower than the maximum permissible limit prescribed by BIS (2012) for drinking water. The limits prescribed are not health based guidelines but for plumbing and laundary.

The fluoride in the analyzed groundwater samples were 0.47 to 1.16 mg/l. Only 3 samples exceeded the acceptable limit prescribed by BIS (2012) for drinking water with respect to fluoride, however all were witing the maximum permissible limit. The groundwater of Siwaya and Pavali Khas needs comprehensive monitoring for fluoride consentrations.

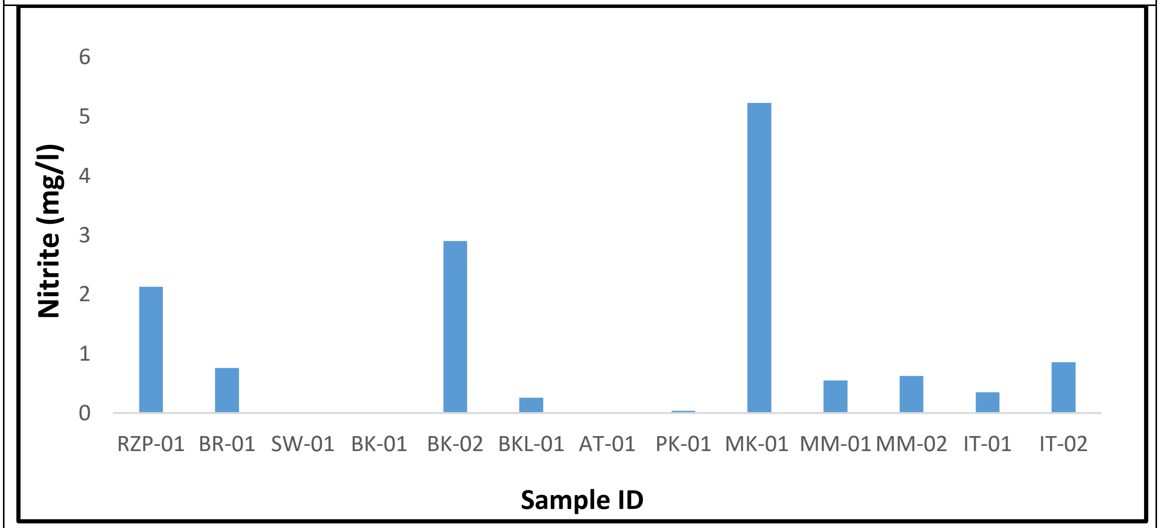
The nitrate concentration in the samples were in the range 0 to 8.18 mg/l which is well within the limit prescribed by BIS (2012). Nitrite was also observed in the groundwater in the samples from nine location indicating anoxic/anaerobic condition and is an indicator of microbial active zone (Figure 10.7 and Figure 10.8).



a. Fluoride

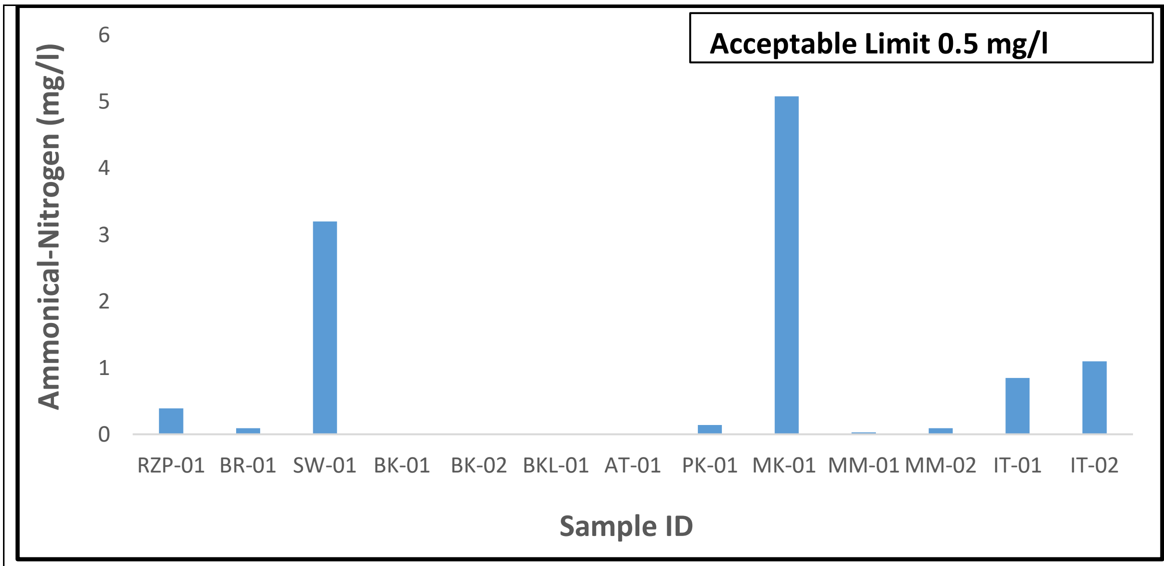


b. Nitrate

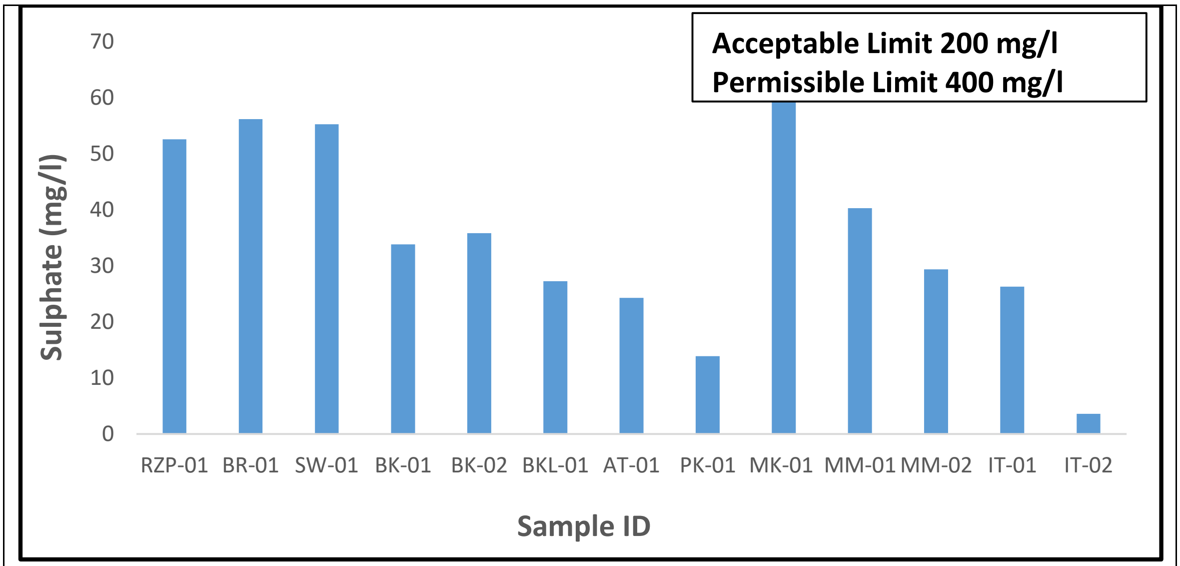


c. Nitrite

Figure 10.7. Fluoride, Nitrate and Nitrite in Groundwater Samples (2017)

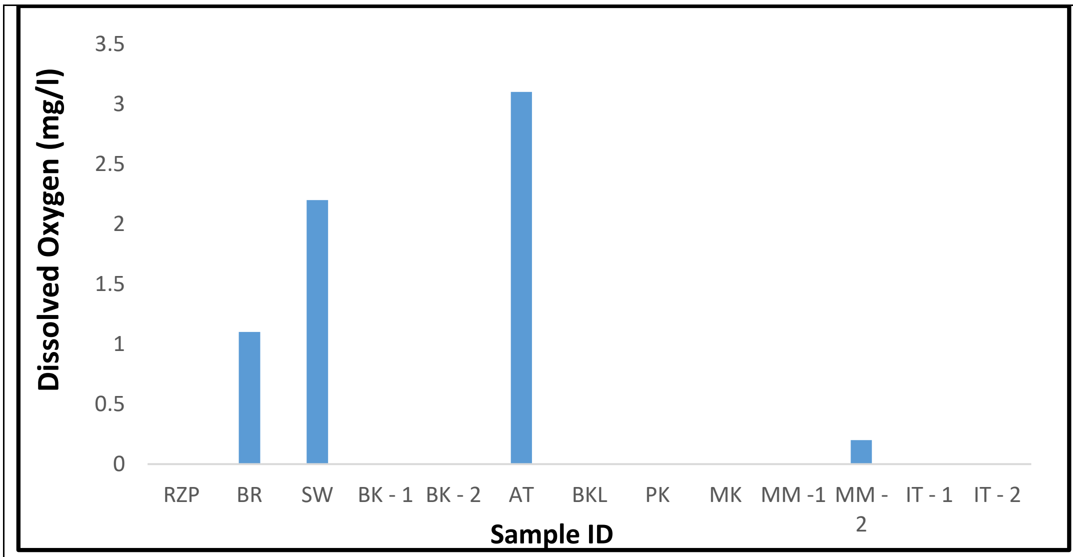


a. Ammonical –Nitrogen

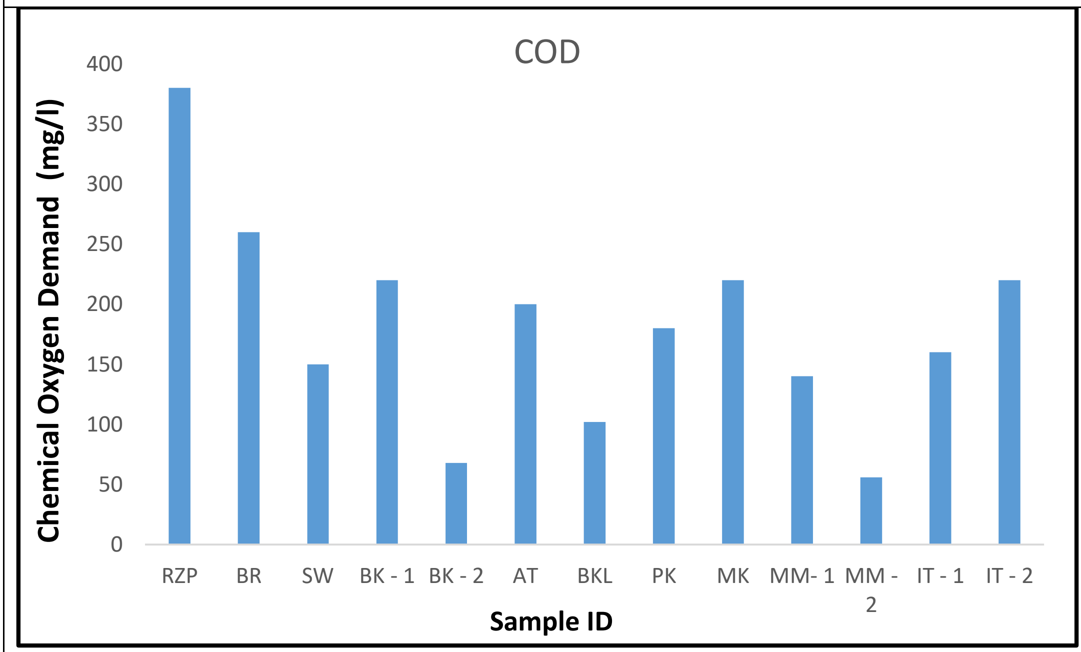


b. Sulphate

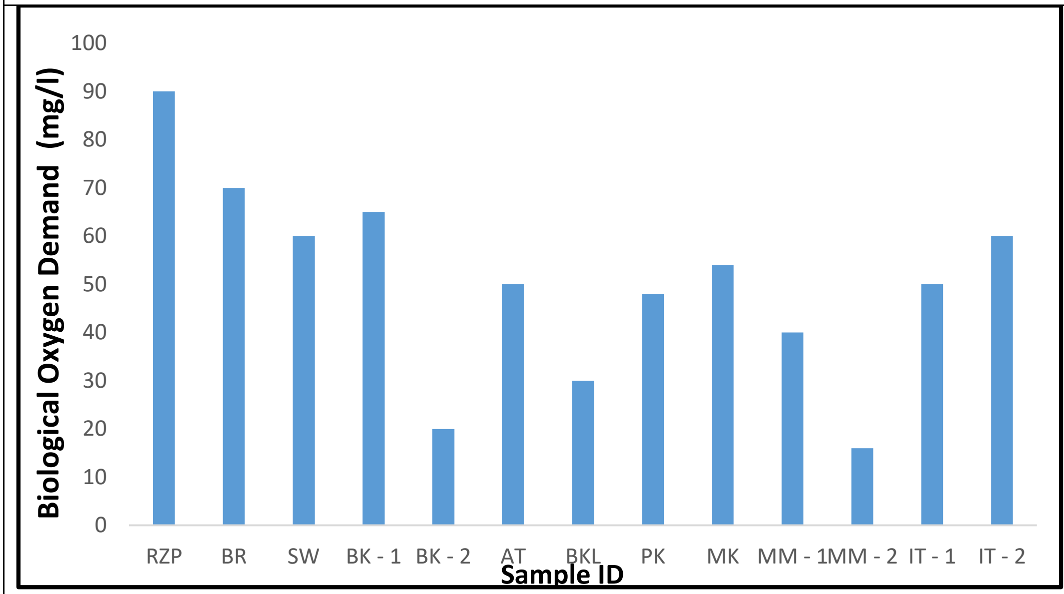
Figure 10.8 Ammonical-Nitrogen and Sulphate in ground water samples (2017)



a. DO



b. COD



c. BOD

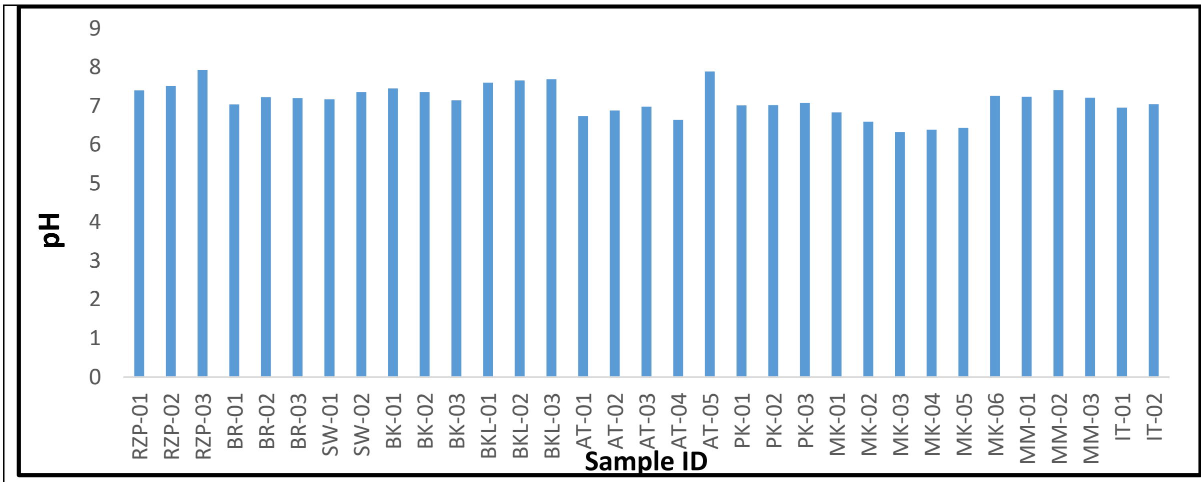
Figure 10.9. DO, COD and BOD in pondwater (2017)

The DO, BOD, and COD concentrations in the pondwater samples were in the range of 0 to 3.1 mg/l, 16-90 mg/l, and 56-380 mg/l respectively. The BOD concentration in the pond water was due to the influx of organics from the incoming domestic wastewater from the village habitation and is sufficient enough to bring down the DO in the pond to near zero. In few ponds, the DO detected in the samples may be because of the photosynthtic activity of algae in the pond which will reduce to zero after sunset and the pond environment is not suitable for the aquatic species, especially fishes (Figure 10.9).

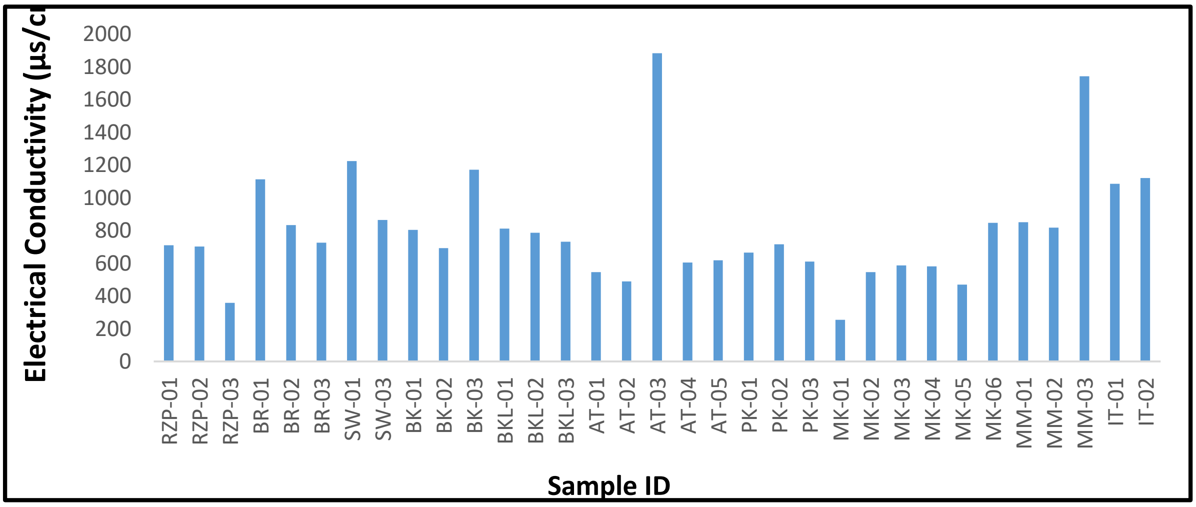
10.2.2 Ground Water Samples (2019)

pH of samples ranged from 6.3 to 7.9 in all the ground water samples. EC values ranged from 489 to 1744 µs/cm.Turbidity of analysed samples varied from 0.5 to 78.9 NTU and turbidity of 45% samples exceeded the permissible limit of 5 NTU as per BIS 2012.Total dissolve solids in ground water samples ranged from 387 to 1205 mg/l.

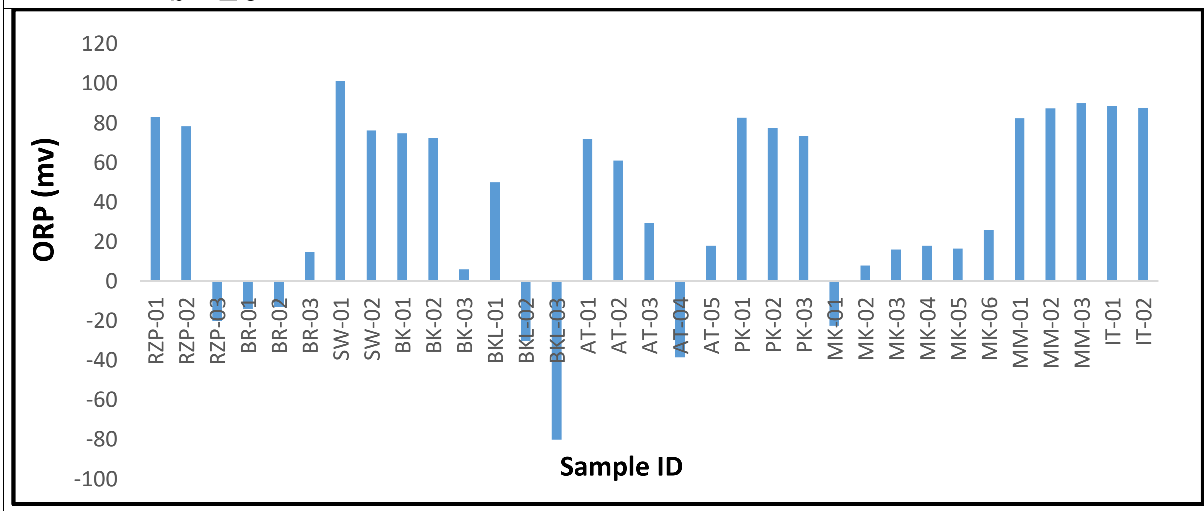
The ORP of the groundwater samples ranged from -80 mV to 101.1 mV with average value 38.61 mV. Slight shift in ORP values were observed towards positive side indicating improvement (Figure 10.10 and Figure 10.11).



a. pH

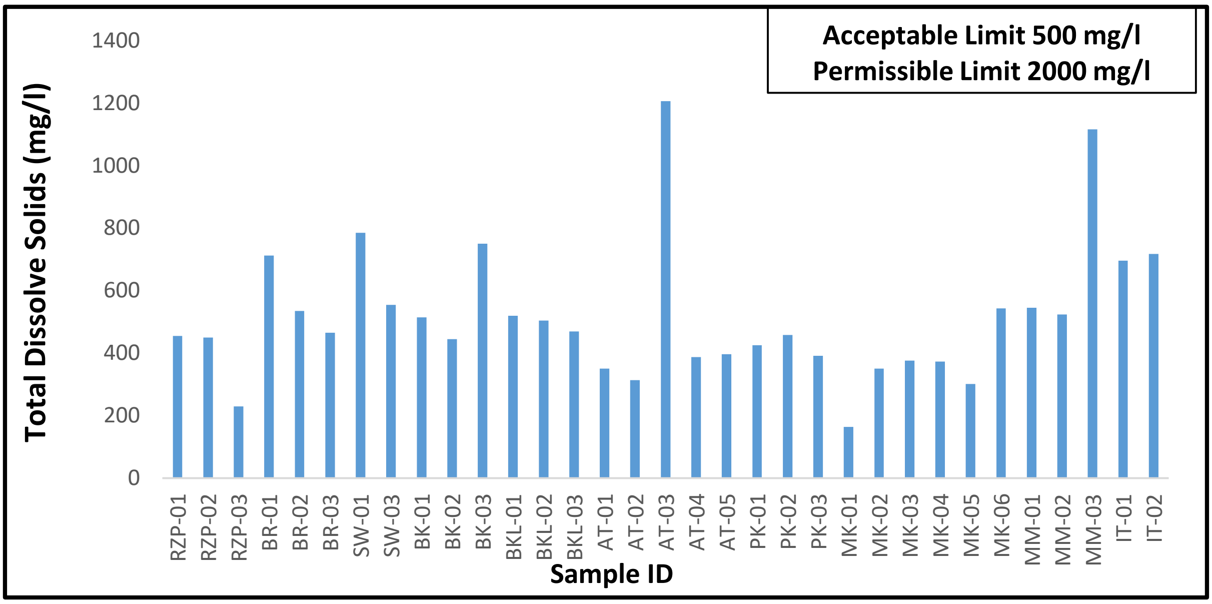


b. EC

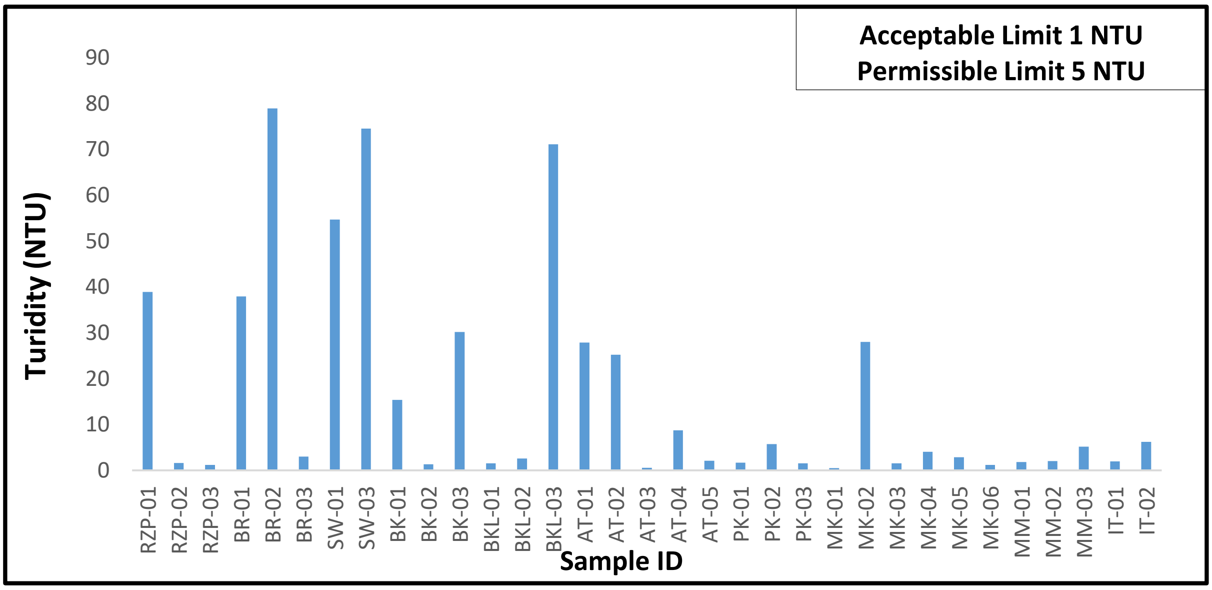


c. ORP

Figure 10.10: pH, EC & ORP of GW Samples (2019)

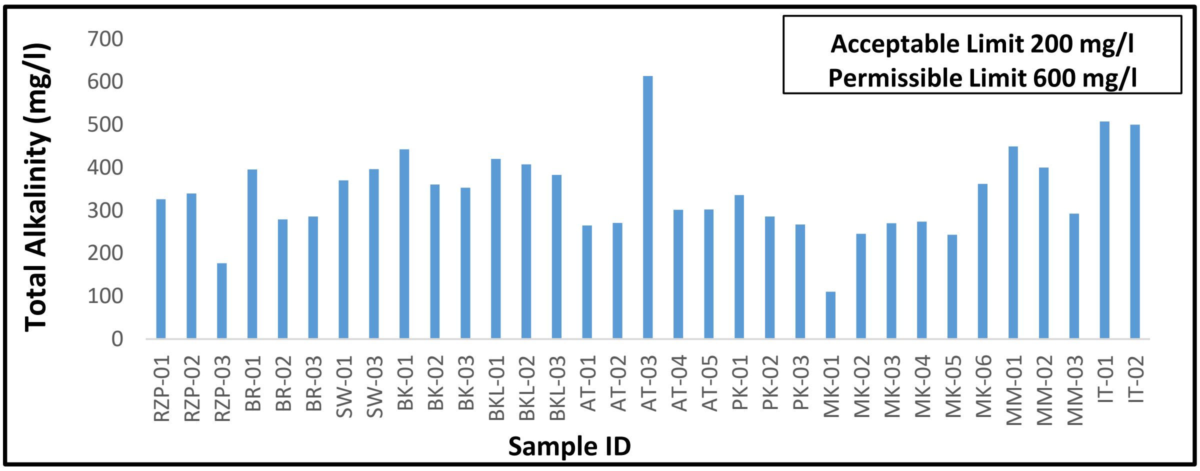


a. TDS

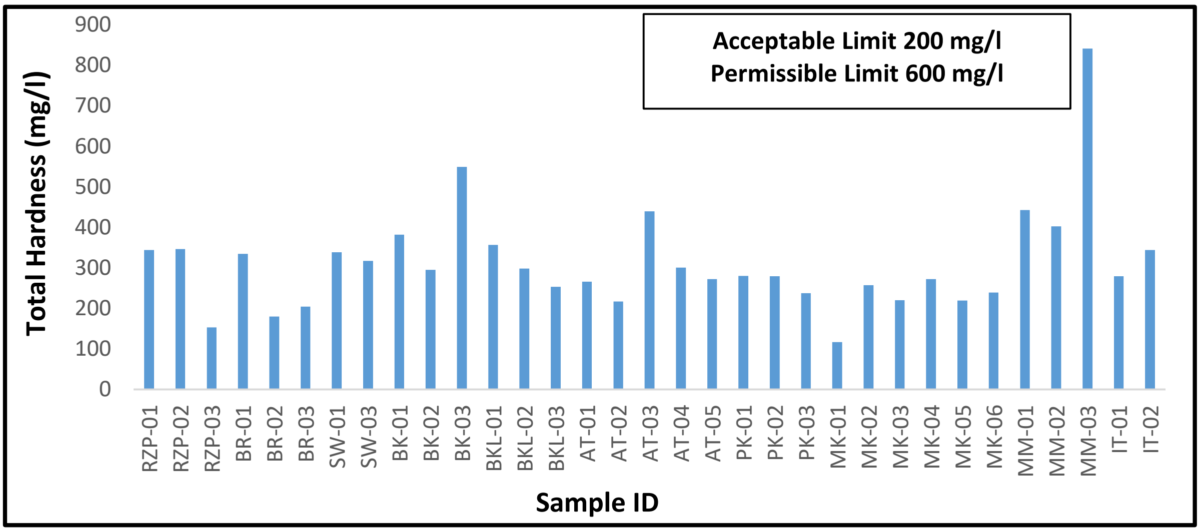


b. Turbidity

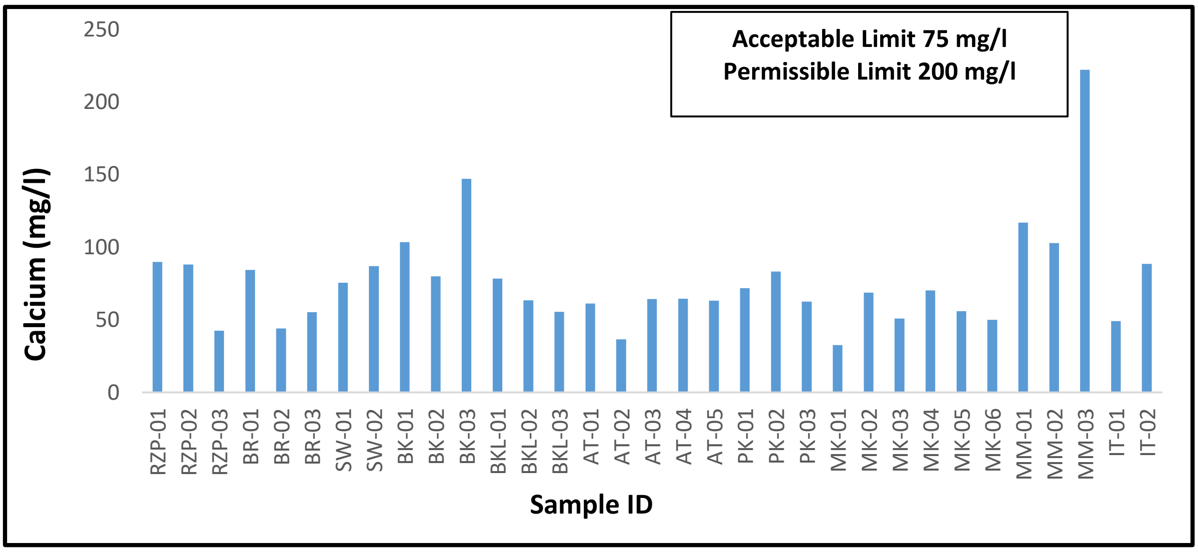
Figure 10.11: TDS and Turbidity in GW Samples (2019)



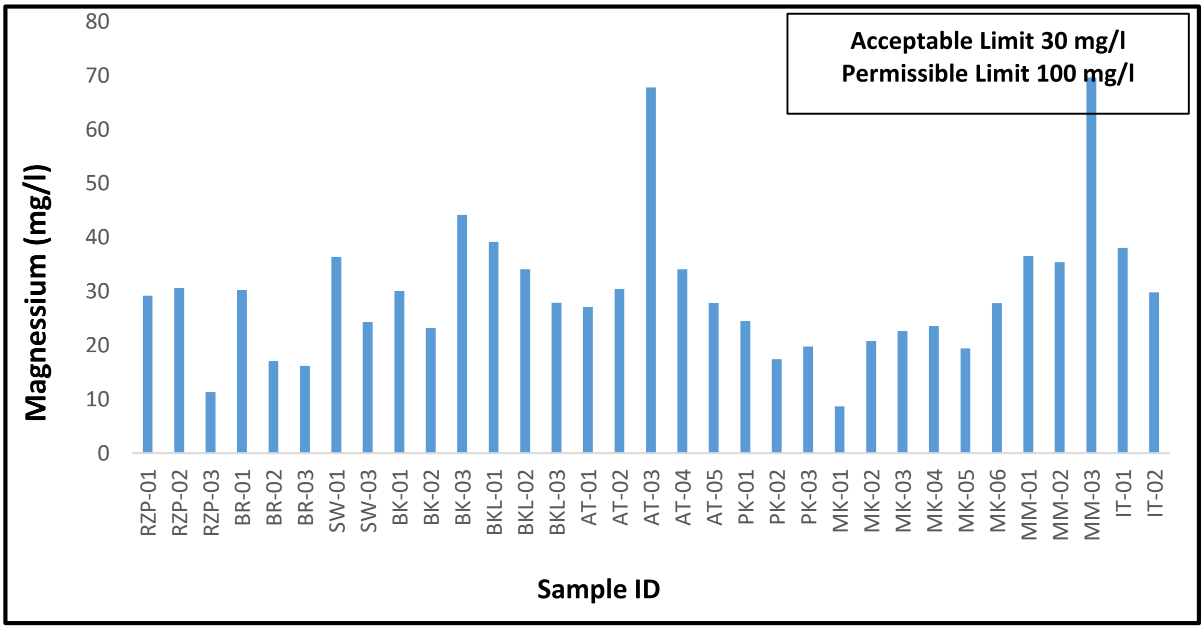
Alkalinity



Hardness



Calcium



Magnesium

Figure 10.12. Alkalinity, Hardness, Calcium and Magnesium in GW Samples (2019)

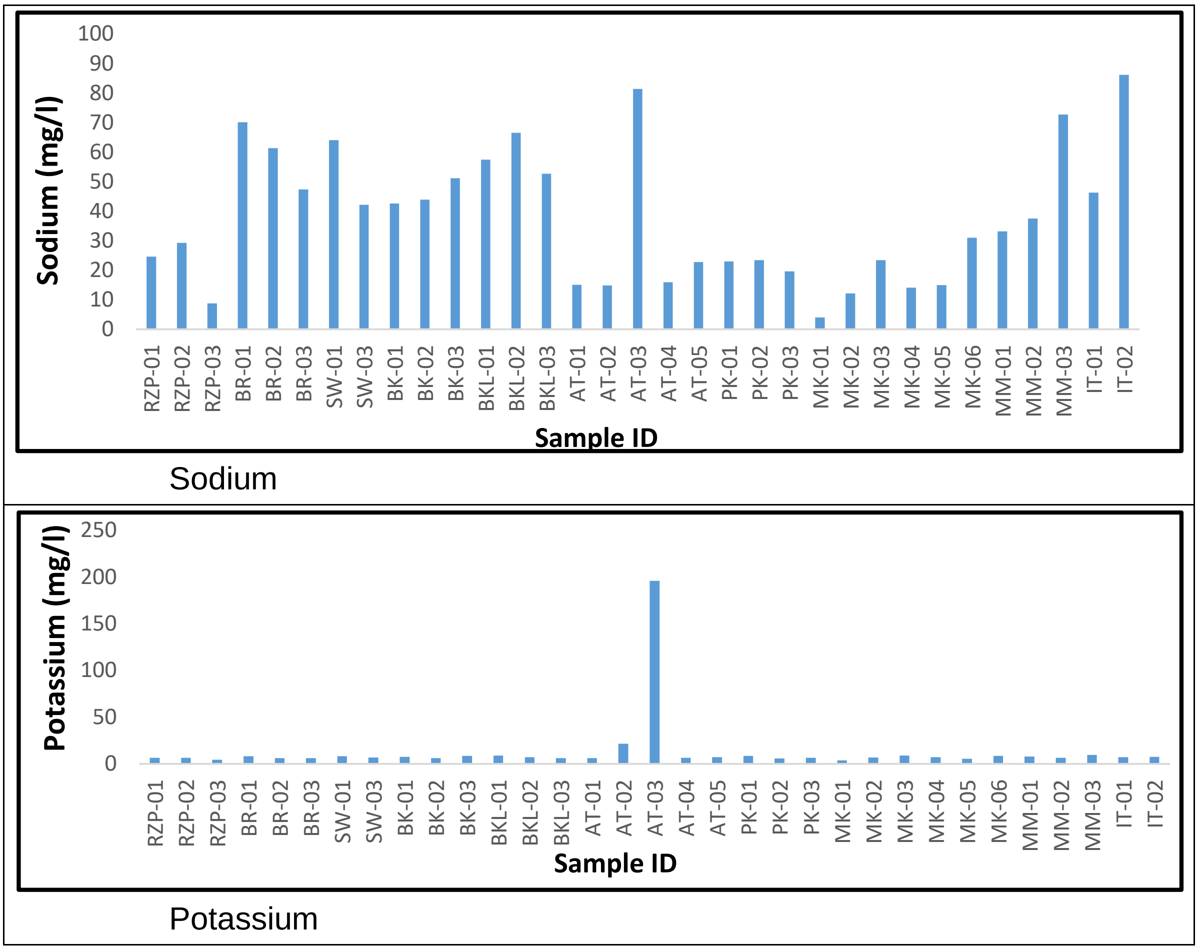
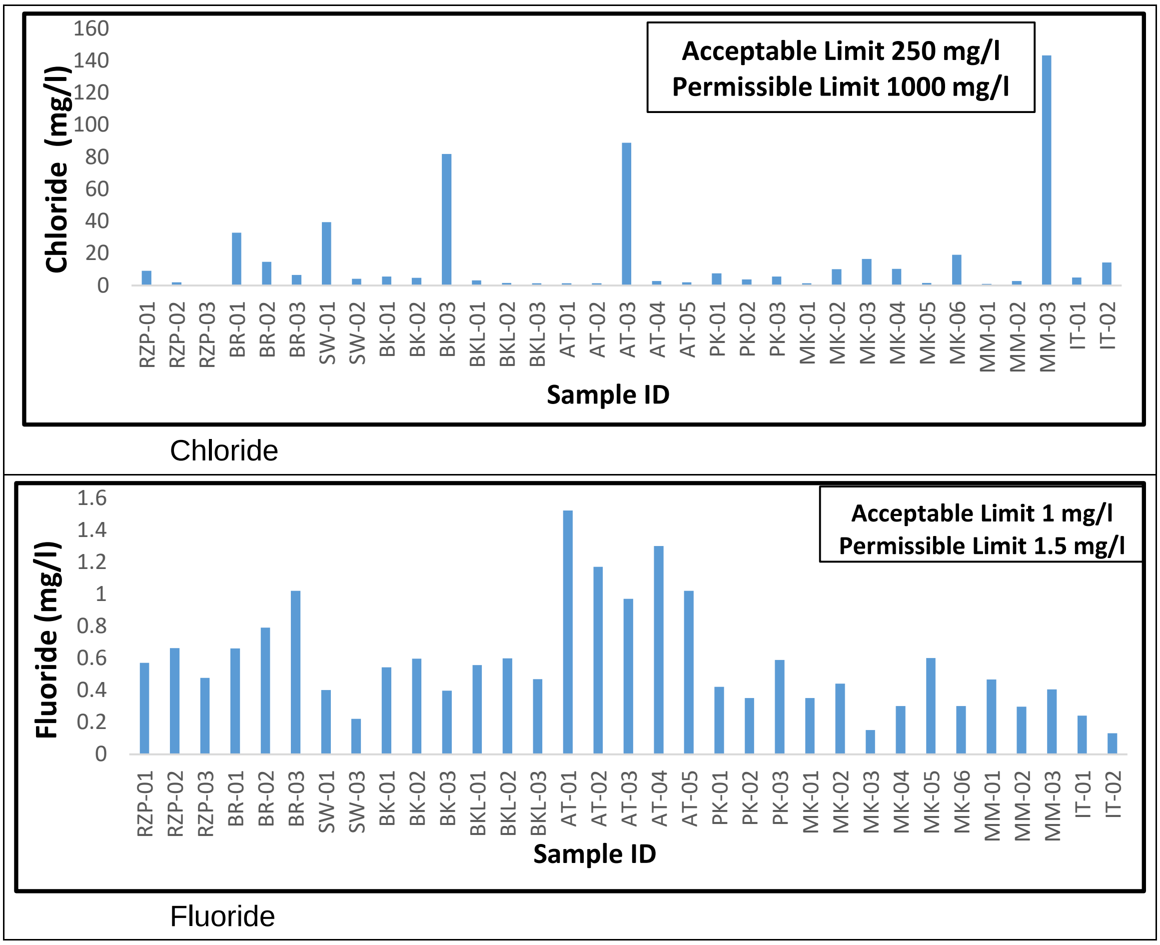
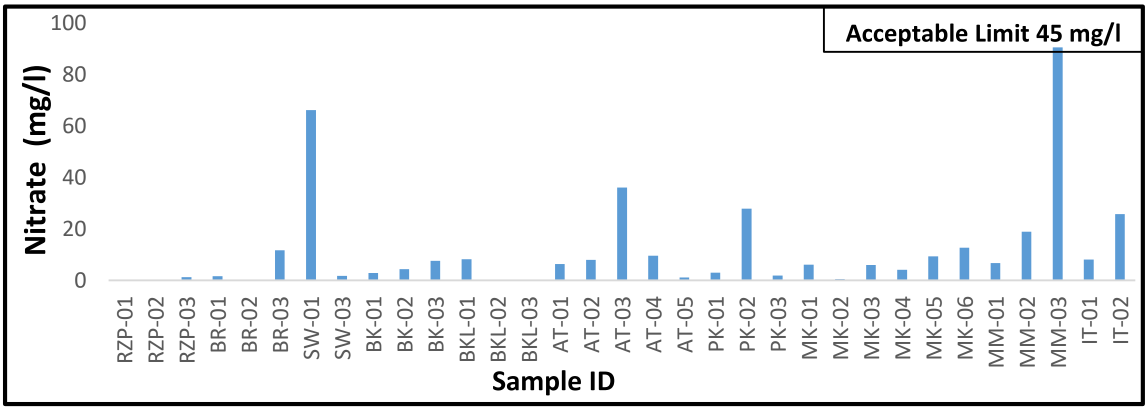
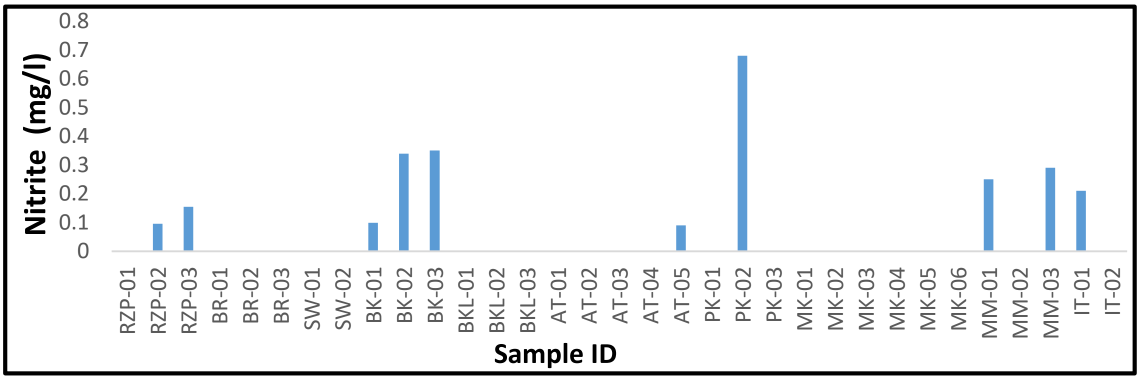


Figure 10.13: Sodium and Potassium in Groundwater Samples (2019)

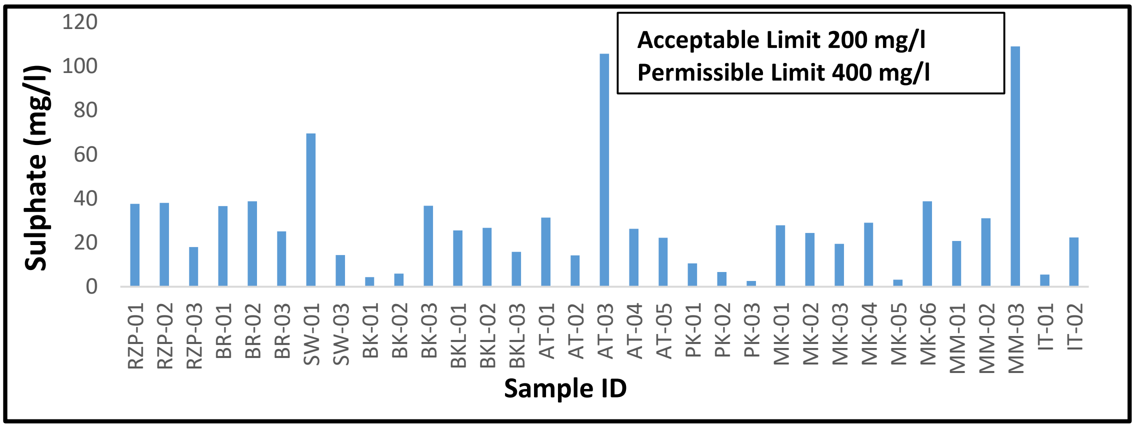




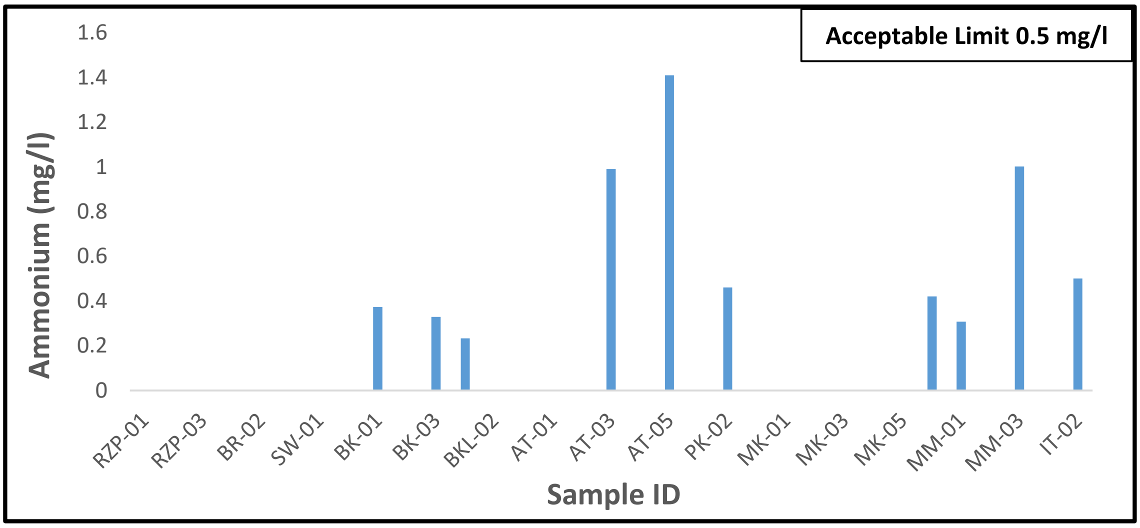
Nitrate



Nitrite



Sulphate



Ammonium

Figure 10.14: Chloride, Fluoride, Nitrate, Nitrite, Sulphate and Ammonium inGW (2019)

The hardness of water samples ranged from 117 mg/l to 841 mg/l, with average value 311.5 mg/l. The Ca and Mg in the groundwater of the study area was observed in the range 32.7-222.4 mg/l and 8.6-69.6 mg/l respectively. Total alkalinity of the samples ranged from 110 mg/l to 613 mg/l. Sodium and potassium in the water samples were in the range 4.1-86.2 mg/l and 3.7-195.7 mg/l respectively. The average concentration of the Na and K in the study area was 38 mg/l and 13 mg/l respectively. The major source of potassium in natural fresh water isweathering of rocks but the quantities increase in the polluted water due to disposal of waste water. Potassium concentration in few samples were higher and indicates potassium bearing minerals or anthropogenic contamination of groundwater (Figure 10.12 and Figure 10.13).

The chloride in natural waters typically exists in low concentrations (less than 100 mg/L) unless the water is classified as brackish or saline.High concentrations of Cl would cause a salty taste in drinking water and accelerate corrosion of water pipes.Chloride value varied from 0.11 to143.17 mg/l in the ground water samples with average value 16.5 mg/l.

Nitrate concentration ranged from 0 to 90 mg/l with two samples exceeding the permissible limit prescribed by BIS (2012) and needs to marked unfit for drinking and cooking.High concentration of nitrate in water samples can lead to the methaemoloinemia (blue baby syndrome) ininfants and prolonged drinking can lead to cancer. Nitrite and Ammonium values ranged from 0 to 0.68 mg/l and 0 to 1.48 mg/l respectively.

Fluoride concentration varied from 0.1 to 1.5 mg/l. All the samples were well with in the limit except one from Antwara (AT-01). High fluoride may be due to leaching from fluoride-richminerals present in the subsurface as well as due to anthro-pogenic activities.Consumption of groundwater with high fluoride results inmottling of teeth or dental fluorosis followed by skeletalfluorosis.

Sulfate ranged from 2.55 to 108 mg/l in ground water samples, with average concentration 28.6 mg/l. Although high levels of sulfate do not cause health issues forhumans, levels higher than 250 mg/L result in a bitter taste in drinking water and may cause a laxative effect in some consumers.Taste impairment varies with the nature of the associated cation; taste thresholds have been found to range from 250 mg/l for sodium sulfate to 1000 mg/l for calcium sulfate. High sulfate levels in drinking water results in gastro-intestinal disorders, and hence, it is recommended that health authorities be notified of sources of drinking water that contain sulfate concentrations in excess of 500 mg/l (WHO, 2011). A common source of sulfate and Ca in groundwater is gypsum ($CaSO_4 \cdot 2H_2O$) (Figure 10.14).

Bacterial contamination in water is indicated by the presence of coliform bacteria that find their way into water resources mostly through untreated sewage and cause waterborne diseases. Microbiological examination of water samples is conducted to determine the sanitary quality and degree of contamination with wastes. Tests for detection and enumeration of indicator organisms, rather than of pathogens, are used. The coliform group of bacteria is the principal indicator of suitability of a water for domestic uses. Escherichia coli (E. coli) is the major species in the fecal coliform group. Of the five general groups of bacteria that comprise the total coliforms, only E. coli is generally not found growing and reproducing in the environment. Consequently, E. coli is considered to be the species of coliform bacteria that is the best indicator of fecal pollution and the possible presence of pathogens. The TC and EC in the groundwater samples of the study area ranges from ND to 2419 MPN/100 ml and ND to 131 MPN/100 ml respectively (Figure 10.15). BIS prescribes absence of coliforms in the drinking water.

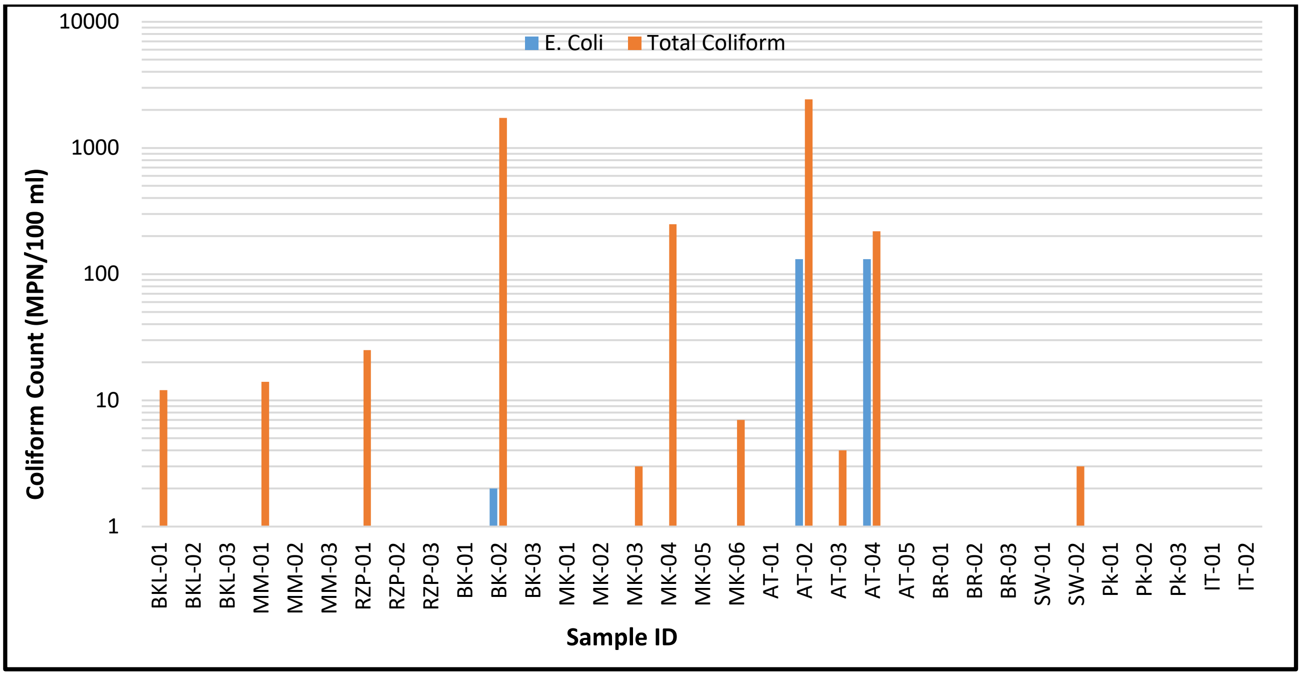


Figure 10.15: Total Coliform and E. Coliform in the GW Samples

10.2.2.1 Trace Metal in Groundwater Samples (2019)

Trace metals in groundwater have a considerable significance due to their toxicity and adsorption behavior. Trace metals are not biodegradable and enter the food chain through a number of pathways causing progressive toxicity due to the accumulation in human and animal organs during their life span on long term exposure to contaminated environments. Despite the presence of trace concentrations of Cr, Fe, Mn, Co, Cu and Zn in the aquatic environment, which is essential to a number of life processes, high concentrations of these metals become toxic. The major sources of trace metals in ground and surface water include weathering of rock minerals and waste effluents on land and runoff water. The unsafe disposal of municipal waste and open dumping also results in increased concentration of trace metals in water. The toxic effects of these elements and extent of their contamination in groundwater is discussed in the following sections.

Aluminum (Al): The Bureau of Indian Standards has recommended 0.030 mg/L as the as desirable limit and 0.20 mg/L as the permissible limit for drinking water (BIS, 2012). The concentration of Aluminum in the ground water of the study area ranges from 0.0123 to 0.7492 mg/L (Fig. 10.16). All the samples of the study area exceeded the desirable limit and around 9% samples exceeded the permissible limit also. It has been hypothesized that aluminum exposure is a risk factor for the development or acceleration of onset of Alzheimer disease in humans.

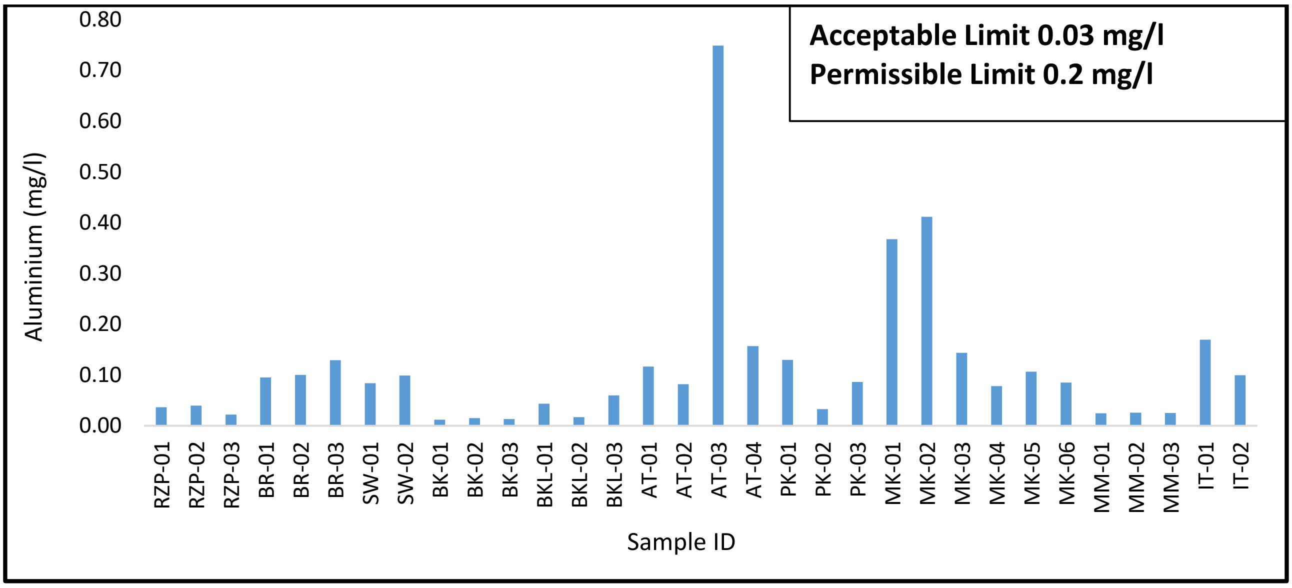


Figure 10.16: Aluminium concentration in the GW Samples

Cadmium (Cd): Cadmium compounds are widely used in batteries. Cadmium is released to the environment in wastewater, and diffuse pollution is caused by contamination from fertilizers and local air pollution. Cadmium accumulates primarily in the kidneys and has a long biological half-life in humans of 10–35 years. There is evidence that cadmium is carcinogenic by the inhalation route, and IARC has classified cadmium and cadmium compounds in Group 2A (probably carcinogenic to humans).Concentration of cadmium in the water samples varies between 0.0 to 0.0063 mg/l (Fig.10.17) with average concentration 0.0011 mg/l, and the concentrations of Cd in around 94% samples were less than BIS-2012 permissible limit (0.003 mg/l) for the drinking water.

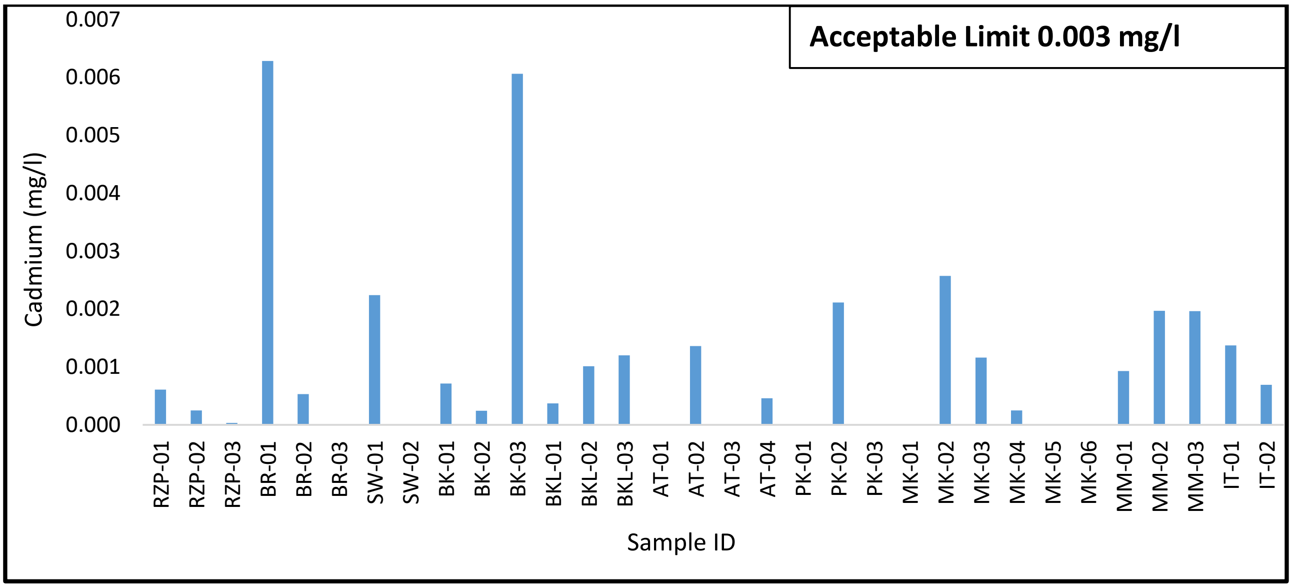


Figure 10.17: Cadmium concentration in the GW Samples

Copper (Cu): Copper is both an essential nutrient and a drinking-water contaminant. It is used to make pipes, valves and fittings and is present in alloys and coatings. Beyond 0.05 mg/l the water imparts astringent taste and cause discoloration and corrosion of pipes, fittings and utensils. Recent studies have delineated the threshold for the effects of copper in drinking-water on the gastrointestinal tract, but there is still some uncertainty regarding the long-term effects of copper on sensitive populations, such as carriers of the gene for Wilson disease and other metabolic disorders of copper homeostasis. The concentration of copper in groundwater of the study area varies between non-detectable to 0.1954 mg/l, with average concentration 0.0233 mg/l (Fig. 10.18). The Bureau of Indian Standards has recommended 0.05 mg/l as the desirable limit and 1.5 mg/l as the permissible limit in the absence of alternate source (BIS, 2012). In the study area, around 91% of the total analysed samples fall in the desirable limit of 0.05 mg/l, and all the samples were well within the permissible limit 1.5 mg/l.

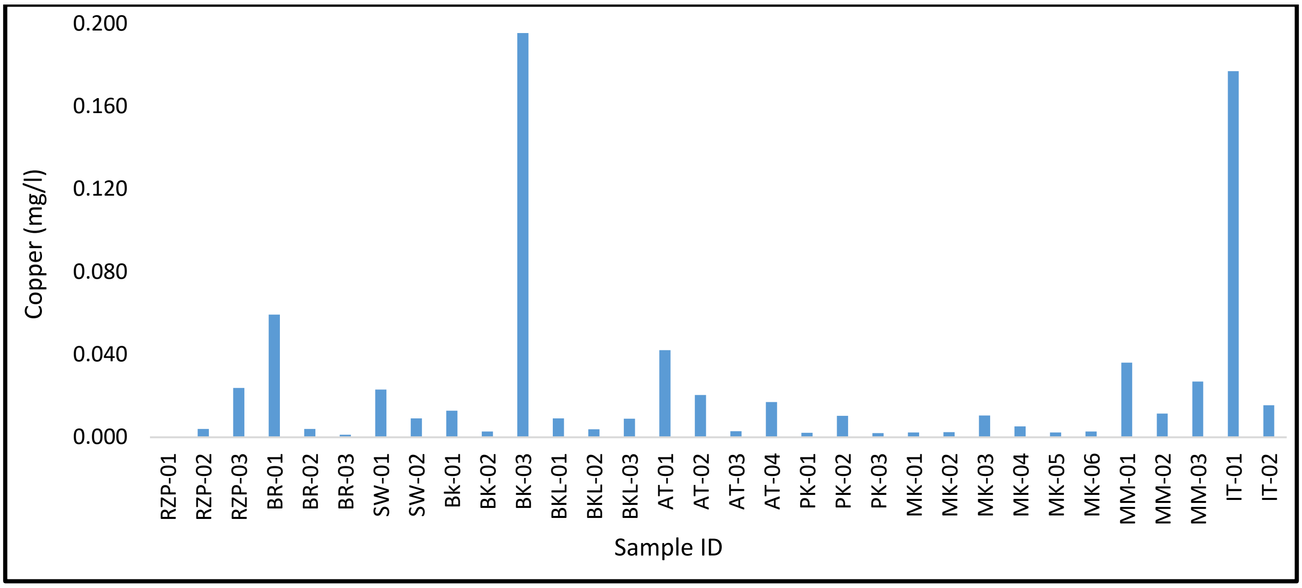


Figure 10.18: Copper concentration in the GW Samples

Chromium (Cr): In water, chromium occurs in two oxidation states, Cr (III) and Cr (VI). Chromium (III) is an essential human dietary element. It is found in many vegetables, fruits, meats, grains, and yeast, while Chromium (VI) occurs naturally in the environment from the erosion of natural chromium deposits. It can also be produced by industrial processes. There are demonstrated instances of chromium being released to the environment by leakage, poor storage, or inadequate industrial waste disposal practices. Concentration of Cr in sampled water varies from 0.0 to 0.0231 mg/l (Fig. 10.19). The acceptable limit prescribed by BIS (2012) is 0.05 mg/l and all the samples were well with the prescribed value.

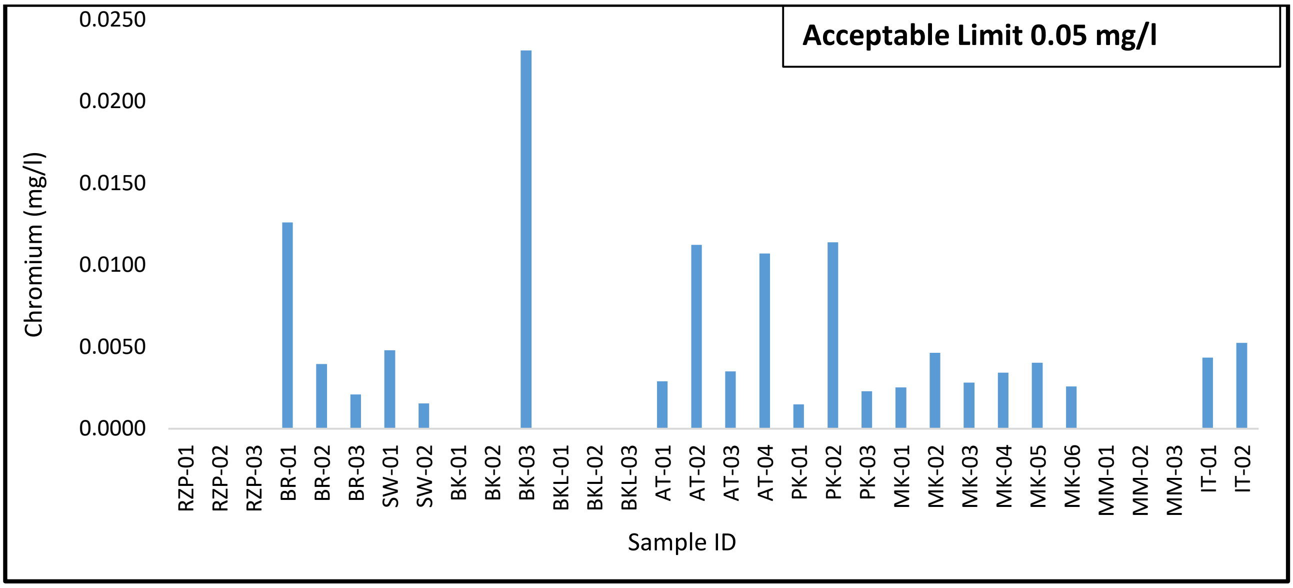


Figure 10.19: Chromium concentration in the GW Samples

Lead (Pb): Lead is used principally in the production of lead-acid batteries, solder and alloys. The organic lead compounds tetraethyl and tetra methyl lead have also been used extensively as antiknock and lubricating agents in petrol, although their use for these purposes in many countries including India has largely been phased out. Exposure to lead is associated with a wide range of effects, including various neuro developmental effects, mortality (mainly due to cardiovascular diseases), impaired renal function, hypertension, impaired fertility and adverse pregnancy outcomes. The concentration of Lead in the water samples of the study area varies between 0.0 to 0.0602 mg/l (Fig.10.20). The concentration of lead in the 40.6% analyzed samples exceeded the permissible limit of 0.01 mg/l prescribed by BIS (2012) and is a matter of concern.

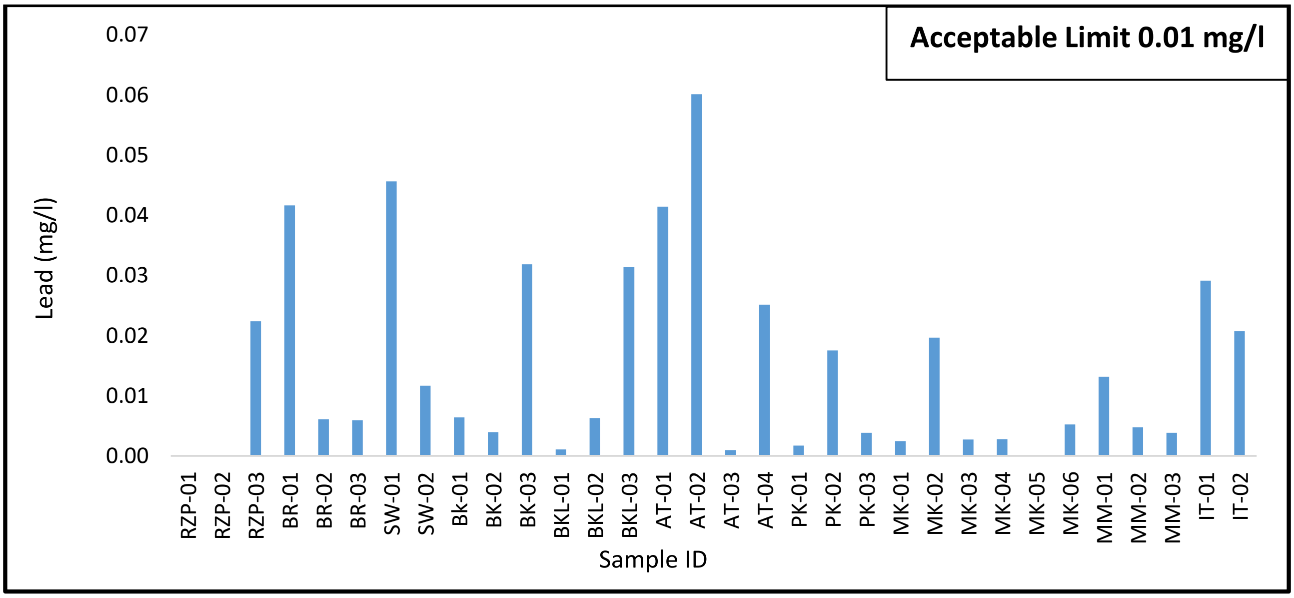


Figure 10.20: Lead concentration in the GW Samples

Manganese (Mn): Manganese is one of the most abundant metals in Earth's crust, usually occurring with iron. It is used principally in the manufacture of iron and steel alloys, as an oxidant for cleaning, bleaching and disinfection (as potassium permanganate) and as an ingredient in various products. More recently, it has been used in an organic compound, methyl-cyclo-pentadienyl manganese tri-carbonyl, or MMT, as an octane enhancer in petrol. Manganese is naturally occurring in many groundwater sources, particularly in anaerobic or low oxidation conditions. At levels exceeding 0.1 mg/l, manganese in water supplies causes an undesirable taste in beverages and stains sanitary ware and laundry. The presence of manganese in drinking-water may lead to the accumulation of deposits in the distribution system. Manganese will often form a coating on pipes, which may slough off as a black precipitate.

The concentration of manganese in the water samples of the study area varies between 0.059 to 0.7795 mg/l (Fig.10.21). The Bureau of Indian Standards has recommended 0.1 mg/l as acceptable and 0.3 mg/l as the as the maximum permissible limit for Mn in drinking water (BIS, 2012). 84.3% analyzed samples exceeded the acceptable limit and 37.5% samples exceeded the maximum permissible limit in terms of manganese concentration.

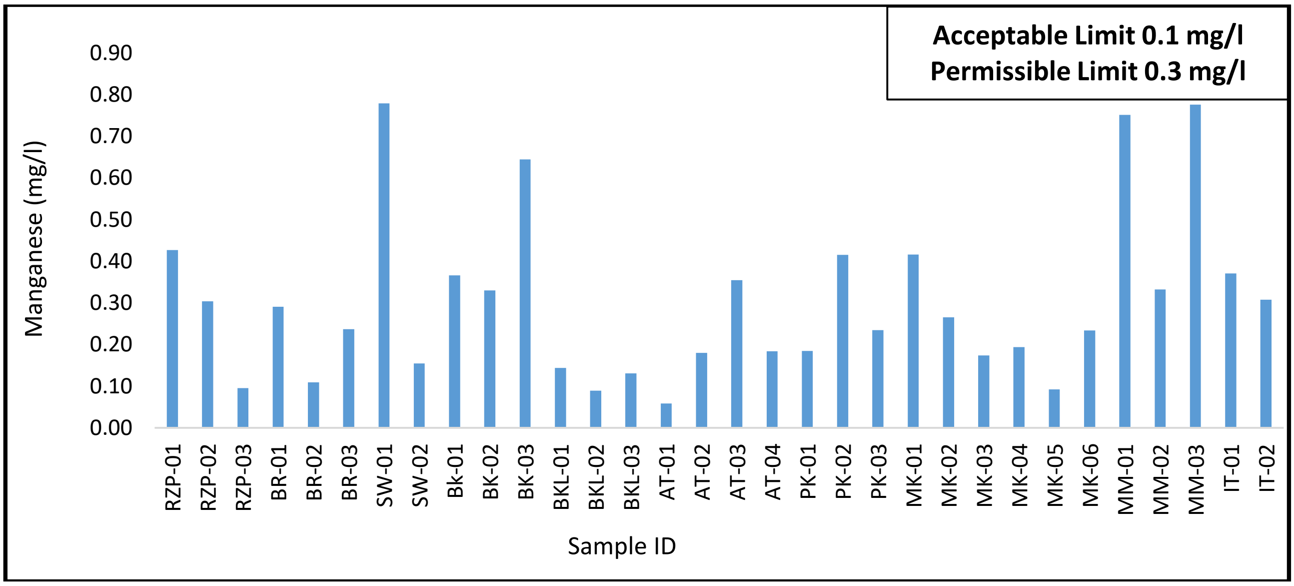


Figure 10.21: Manganese concentration in the GW Samples

Zinc (Zn): Zinc is an essential trace element found in virtually all food and potable water in the form of salts or organic complexes. The solubility of zinc in water is a function of pH and total inorganic carbon concentrations; the solubility of basic zinc carbonate decreases with increase in pH and concentrations of carbonate species. In general, concentration of zinc in surface water and groundwater normally do not exceed 0.01 and 0.05 mg/l, respectively. The concentration of zinc in the groundwater samples varies between 0.0424 to 6.4904 mg/l (Fig. 10.22). The Bureau of Indian Standards has recommended 5.0 mg/l as the desirable and 15.0 mg/l as the maximum permissible limit for drinking water (BIS, 2012), and 6.2% analysed samples exceeded the acceptable limit, however, all the samples are well within the permissible limit.

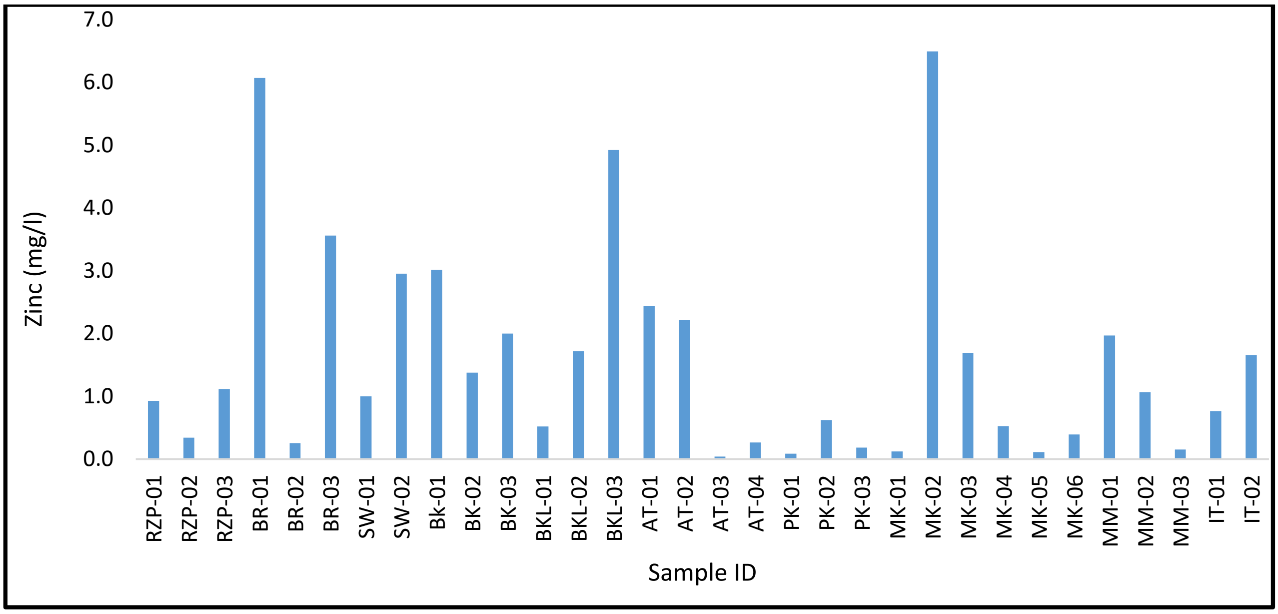


Figure 10.22: Zinc concentration in the GW Samples

10.3 Trophic Status of Ponds

The trophic condition of a water body is expressed in terms of Trophic State Indices (TSI), which represent the energy dynamics of nutrients loading and aquatic community in the water body. TSI representation using multiple parameters (e.g. chlorophyll, phosphorous, Secchi disk, nitrogen) indicates the trophic status as a continuum. This facilitates classifying and ranking water bodies by trophic state and is useful for communication. The action plan for pond management requires defining the problems, identifying causes, examining feasible management alternatives, and implementing remedial measures to achieve the desired results. An integrated approach using TSIs, phytoplankton community index and water chemistry characteristics, therefore, adequately reflects the perceived problems and can be easily related to the intended management plan.

Quality of an aquatic ecosystem is dependent on the physico-chemical characteristics as well as the biological diversity of the system. The physico-chemical characteristics of ponds are given in Table 2. Temperature is one of the important characteristic of an aquatic ecosystem that affects the metabolic rates and level of dissolved oxygen. Water temperature ranged from 25 to 35^{o}C. The pH of the ponds varied from 7.2 to 9.3. 25% of the samples were having pH more than 8. High pH in the ponds may be due to the uptake of CO_2 by the plants for photosynthesis, resulting in the reduced concentration of H_2CO_3 in the water. Moreover, the high pH values may also be due to the sewage discharged from agricultural fields, addition of soap and other household ingredients into water(Mohammad et al., 2015).The Electrical conductivity (EC)of water reflects the nutrient status of water and distribution of macrophytes. EC of the ponds ranged from 1303 to 2280 µS/cm. Higher value of EC in ponds is due to the discharge of salts from the households and agricultural field (Ekhalak et al., 2013). Dissolve oxygen (DO) is the most important parameter for aquatic flora and fauna. DO varied from 0 to 3.1 mg/l. Low DO indicates the eutrophic condition of ponds. Bhattacharyya & Ghosh (2018) reported that under low level of DO, organic matter starts decomposing thereby utilizing the oxygen in water. Biochemical oxygen demand **(**BOD) is a good index of pollution status and therefore helps in deciding the suitability of water for utilization. Human and animal activities in the pond e.g. washing, defecation etc. leads to a high concentration of organic load, and BOD level varied from 16 to 90 mg/l in the ponds. Further, Chemical oxygen demand (COD) was 56 to 380 mg/l in ponds, which indicates that organic waste is entering into ponds, whose probable sources include sewage discharges, agricultural runoff and animal habitat runoff water. Total nitrogen (TN) concentration ranged from 48.72 to 514 mg/l and total phosphate (TP) concentration ranged from 1.98 to 30 mg/l. The concentration of TN is higher than the TP in all ponds as it does not readily sorb to soil particles. High level of phosphate in pond water results in increased productivity of algae. Concentration of phosphate in the pond water was more than 0.02 mg/l, confirming eutrophic condition of the ponds as also reported by Kilpimaa et al., (2014); Mor et al., (2016). ME-1, MN-4, MN-7, MN-8 and MN-9 have especially high values of TP.TN and TP ratio indicates which nutrient would have the limiting impact that dominate the growth of algae in ponds. Ayoadeet al. (2019) reported if TN/TP ratio is greater than 7, phosphorus will be the limiting nutrient, whereas for TN/TP ratios below 7, nitrogen will be the limiting for algal growth. As the TN/TP ratio is very high (1.62 to 253.54) in all the ponds, phosphorous is the limiting nutrient for algal growth (USEPA, 1974). Secchi depth, which is generally related with the plankton's growth was 0.04 to 0.16 m. Dirt and the suspended particles in ponds prevent sunlight to reach the planktons which results in depletion of the oxygen level.

10.3.1 Trophic State Determination Using Different Trophic Indices

The trophic status of a water body is calculated by a combination of quality parameters like water clarity and light penetrance, chlorophyll-*a* concentration as a measure of algal activity and phosphorus concentration, an essential nutrient needed by aquatic plants and algae to grow. The protocol classifies lakes as eutrophic, mesotrophic or oligotrophic. The dynamic nature of the productivity and eutrophication due to natural and anthropogenic factors leaves no single assessment variable as a true measure of the eutrophication status of a given water body (Xu et al., 2001; Padisak et al., 2009) and a combination of physical and chemical parameters are widely used in determining the health of an aquatic ecosystem (Phillips et al., 2013). Also, the health of water body can be determined by the phytoplankton in both lotic and lentic environments and are considered to be a reliable measure of environmental health depicting different levels of eutrophication (Wetzel, 1983; Xu et al., 2001; Soylu & Gönülol, 2010; Ferreira et al., 2011; Demir et al., 2014).

i. Trophic Status Index

Carlson's trophic status index (Carlson, 1977) has been widely used by the researchers for estimating the trophic status of water bodies. This method is based on three parameters namely chlorophyll - a (Chl-a), secchi depth (SD) and total phosphate (TP) in a water body. Kratzer & Brezonik (1981) concluded that the total nitrogen (TN) content of the water body also impacts the productivity and incorporated the same for calculation of the composite trophic status index (CTSI). In the present work, the Kartzer & Brezonik approach was adopted to compute the CTSI using the following equation:

$$CTSI = \frac{TSI(SD)+TSI(Chl-a)+TSI(TP)+TSI(TN)}{4} \qquad (1)$$

Where

$$TSI(SD) = 60 - 14.41\ln(SD)$$

$$TSI(Chl-a) = 9.81\ln(Chl-a) + 30.6$$
$$TSI(TP) = 14.42\ln(TP) + 4.15$$
$$TSI(TN) = 14.43\ln(TN) + 54.45$$

TP and Chlorophyll-a are in µg/l, and SD transparency in meters. Based on the values of CTSI, the ponds are classified as oligotrophic, mesotrophic, eutrophic, and hyper-eutrophic (EPA, 1979).

The TSI of the ponds were in the range of 107 to 118 (Table 10.2) indicating hypereutrophic character (EPA, 1979). This is due to regular discharge of nutrients through the domestic wastewater and run-off from the agricultural fields, which promotes the productivity of phytoplankton and other macrophyes in the ponds (Gupta et al., 2014; Sharma et al., 2013). Further, the growth and decay of planktons and macrophytes may lead the ponds towards anoxic conditions (Silkin et al., 2019) a case observed in the present study. Because of the anoxic/anaerobic conditions, the fish and other zooplanktons are reduced resulting in the imbalanced ecosystem of the ponds.

ii. Nygaard's Algal Index

Nygaard's index (1949) includes Chlorophycean index, Desmediacean index, Euglenophycean index, Bacillariophycean index, and Cyanophycean index. The combination of these indices is compound coefficient index. All these are useful in determination of the trophic status of a pond or a lake, and are calculated using the following formula:

$$\text{Myxophycean index } = \frac{Myxophyceae}{Desmidaceae} \quad (2)$$

$$\text{Chlorophycean index } = \frac{Chlorococcales}{Desmidaceae} \quad (3)$$

$$\text{Euglenophycean index } = \frac{Euglenophyceae}{Myxophyceae + Chlorococcales} \quad (4)$$

$$\text{Compound Coefficient } = \frac{Myxophyceae + Chlorophyceae + Bacillariophyceae + Euglenophyceae}{Desmidaceae} \quad (5)$$

The trophic status was further evaluated by using the Nygaard's indices (1949) for different groups of algae i.e., myxophycean, chlorophycean, diatoms, euglenophycean, and a Compound Quotient (CQ) was used to get a meaningful evaluation of the extent of pollution in the water. The CQ value less than 0.24 indicates ultraoligotrophic nature, 0.24-1.8 oligotrphic, 1.8-3.0 oligomesotrophic. 3.0-4.2 mesotrophic, 4.2-5.4 mesoeutrophic, 5.4 – 10 eutrophic, and greater than 10 hypereutrophic. The CQ values in the present study ranged from 4.5 to 6.89 as given in Table 3, indicating all the ponds mesoeutrophic except one at Munnawarpur Kalan, which was identiifed as eutrophic (Yang,1990). The coefficient of algal indices indicates that cynophyceae species were more dominant in all the ponds (1.2 to 2.65) among all the species observed in ponds.

iii. Shannon-Weaver Diversity Index

A diversity index is a mathematical measure to summarize the diversity of a population in which each member belongs to a unique group in a community. Shannon-Weaner's index (H) is commonly used to characterize the species diversity in a community

(Shannon and Weaver, 1964). This index accounts for both abundance and evenness of species present. The following equation is used to calculate the Shannon-Weaner's Index:

$$H = -\sum[(pi).\ln(pi)] \quad (6)$$

Where

pi is the proportion of individuals of one particular species found divided by the total number of individuals found, In is the natural log, Σ is the sum of the calculations.

Shannon-Weaver's diversity index was used to understand the number of species richness and the distribution of individual species in the ponds, which is considered a good indicator of the extent of pollution in the water body. The computed diversity index of the diatom species is shown in Table 4. The values of the Shannon index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized as moderate pollution and values less than 1 are characterized as heavily polluted (Dhar et al., 2017). In the present study, the Shannon'sDiversity Index values were in the range 1.4-1.5, indicating moderately polluted status of the ponds.

10.3.2 Phytoplankton Characteristics

In aquatic system phytoplankton are important component and an indicator of the sound health of the water body (Ekhalak et al., 2013). Phytoplankton includes blue-green algae, green algae, diatoms, euglenoids, and are important among aquatic flora. In the present study, 25-37 genera of Green Algae (Chlorophyceae), 7–16 genera of Desmids (Desmidiaceae), 2-11 genera of Dianoflagelets (Euglophyceae), 11 - 29 genera of Diatoms (Bacillariophyceae) and 19 - 27 genera of Blue Green (Cyanophyceae) species were identified in the ponds and recorded in the Table 10.3 and Figure 10.23. The Cyaniphycean algae namely Anabaena and Microcystis were dominant in all the ponds. The blooms of Cyanophyceae is an indicator of eutrophic waters and is represented by the species of Anabena, Microcystis, Oscillatoria, Lyngbya etc. (Silkin et al., 2019).

Chlorophyceae was predominant in all the ponds. Chlorophyceae members grow well in water that is rich in nutrients such as nitrate and phosphate (Thakur et al., 2014) and this may be one reason for the abundance of the Cholrophyceace members. Pediastrum species was also observed in the pond water in lower quantities. This species generally grows in waters with low nutrients. This observation is in contrast to the observations made by other researchers (Rawson,1956; Sandgren, 1988). Also, desmids like Cosmarium, Closterium species were observed in all the ponds which are indicators of the oligotrophic waters (Round, 1957; Rawson, 1956; Palmer, 1969; Garg et al., 2006; Tiwari et al., 2006). This may be due to the different climatic conditions of the study area as compared to other workers. Moreover, high diversity of diatoms in the ponds of the study area indicates the driving parameters like pH, nitrate, phosphate & BOD favouring the growth of diatoms. Also, the presence of species native to oligotrophic waters is a good sign for revival of the pond eco-system after adopting appropriate remedial measures.

Table 10.2: Water quality and trophic status index of identified ponds

Sr. No.	Village ID	pH	EC (µS/cm)	Temp. (ºC)	DO (mg/l)	COD(mg/l)	BOD (mg/l)	Chl- a (µg/l)	TP(µg/l)	TN (mg/l)	Secchi Depth (m)	Composite TSI (CTSI)	TSI of Statusas per Carlson's Index
1	**ME–1**	8.1	1647	32	Nil	180	48	330	29500	410	0.16	116	Hyper Eutrophic
2	**ME - 2**	7.7	1675	28	2.2	150	60	180	1980	502	0.11	107	Hyper Eutrophic
3	**MN- 1**	9.3	1303	34	Nil	102	30	290	4290	412	0.11	111	Hyper Eutrophic
4	**MN - 2**	7.6	1660	30	Nil	220	65	310	6240	416	0.04	116	Hyper Eutrophic
5	**MN - 3**	7.5	1483	33	0.2	56	16	180	3200	474	0.06	111	Hyper Eutrophic
6	**MN - 4**	8.2	1735	33	1.1	260	70	300	13920	512	0.15	115	Hyper Eutrophic
7	**MN - 5**	7.7	2170	35	Nil	220	60	450	6980	432	0.06	116	Hyper Eutrophic
8	**MN - 6**	7.3	1770	30	Nil	68	20	300	5230	433	0.10	112	Hyper Eutrophic
9	**MN - 7**	7.6	2280	30	Nil	380	90	480	28090	452	0.13	118	Hyper Eutrophic
10	**MN - 8**	7.6	1909	33	3.1	200	50	310	13770	514	0.12	115	Hyper Eutrophic
11	**MN - 9**	7.4	1645	25	Nil	220	54	490	30000	48.72	0.15	110	Hyper Eutrophic
12	**MN - 10**	7.2	1540	35	Nil	160	50	400	4490	426	0.04	115	Hyper Eutrophic

10.3.3 Statistical Analysis

The relationship between the physico-chemical parameters and biological parameters pertaining to the trophic status of a water body was investigated by Pearson's correlation coefficient (r) using Microsoft Excel-2007. The correlation coefficient ranges from -1 to 1. A positive correlation indicates that both the variables increase or decrease together, whereas a negative correlation indicates that as one variable increases, the other decreases and vice-versa.

A correlation analysis of the parameters namely pH, conductivity, temperature, DO, BOD, COD, chlorophyll-a, total phosphate, total nitrogen, sechhi depth, and plankton density which are drivers of the trophic status of the water body was carried out to understand the relation and the parameter most responsible for the eutrophied nature of the ponds of the study area. pH did not showed any significant correlation with other drivers. Conductivity of the water which is indirect measure of the dissolved solids showed significant positive correlation with the COD, BOD, Chlorophyll-a, and CTSI of the water body. Water temperature showed positive correlation with the total nitrogen and CTSI, and this indicates that the temperature is also playing an important role in the productivity of water body. COD and BOD values showed positive correlation with EC, Chlorophyll-a, phosphate, Secchi depth and CTSI, which indicates microbial oxidation of organics taking place in water producing organic acids which may lead to increase in conductivity. Moreover, the input to the ponds is domestic effluent from the villages carrying nutrient load along with organic load. In addition, the decomposition of the aquatic plants results in release of carbon and nutrients and hence this positive correlation is expected. DO concentration in the water showed positive correlation with the phytoplankton density because of photosynthesis activity. Chlorophyll-a content showed significant positive correlation with EC, phosphate and CTSI indicating the productivity. Total phosphorus content is having a significant positive correlation with the secchi depth and organic content. CTSI of the ponds showed significant positive correlation with EC, organics, and chlorophyll-a and positive correlation with phosphorus and nitrate, indicating that the parameters like conductivity, organics, and chlorophyll-a content of the water should be considered for evaluating the CTSI and are the driving factors of eutrophication in the study area.

The following conclusions are drawn from this study:

- The ponds are mostly anaerobic/anoxic due to the microbial degradation of the organics in the pond. In addition, the water was observed to be rich in organics and nutrients.
- The CTSI of the ponds was in the range of 107 to 118 indicating hypereutrophic status. However, the Nygaard's index and Shannon-Weaver's diversity index indicated the water to be meso-eutrophic. This was due to the presence of some oligotrophic species in the waters indicating potential of faster revival of ponds once appropriate control measures are adopted.
- The correlation analysis of the water quality parameters along with the phytoplankton density and CTSI indicated that conductivity, organics, and chlorophyll-a have significant positive correlation with the productivity of water for the studied ponds, and should be considered for evaluating the health of the water bodies in tropical climate.

Table 10.3(a): Identified Phytoplankton Species in Ponds (before rejuvenation)

	Chlorophyceae		Desmediaceae		Euglinophyceae		Bacillariophyceae		Cyanophyceae
1	Ankistrodesmus falcatus	1	Closteridium tetani	1	Euglena elongata		**Pennals Diatoms**	1	Anabaena aequalis
2	Arthrodesmus icus	2	Closteridium acerosum	2	Euglina gracilus	1	Amphora bitumida	2	Anabaena affinis
3	Chalodomonas reinhardtii	3	Closteridium ehrenbergii	3	Euglina viridis	2	Asterionella formosa	3	Anacystis cyanea
4	Chlorella Pyrenoidosa	4	Cosmarium biratum	4	Euglena sanguine	3	Caloneis amphisbaena	4	Aphonacapsa montana
5	Chlorella vulgaris	5	Cosmarium vexatum	5	Phacus acuminatus	4	Cocconeis scutellum	5	Aphanizomenon flos-aquae
6	Chlorococcum botryoides	6	Cosmarium granulatum	6	Phacus oribicularis	5	Cymbella cistula	6	Arthospira maxima
7	Chlorococcumhumicola	7	Desmidium grevillea	7	Phacus curvicauda	6	Cymbella laceolata	7	Chrococcus turgidus
8	Cladophora aegagropila	8	Echinella oblonga	8	Phacus curvicauda	7	Cymbella timudula	8	Chroococcus minor
9	Cladophora glomerata	9	Euastrum angulatum	9	Petalomonas abcissa	8	Diatoma elongatum	9	Chroococcus minutus
10	Coelastrum microsporum	10	Gonatozygon monotium	1 0	Trachelomonas volvocina	9	Diatoma vulgare	10	Gloeothece linearis
11	Eudorina elegans	11	Netrium digitus	1 1	**Euglinophyceae**	10	Egleana rubra	11	Gleotrichia echinulata
12	Glaucocystis nostochinearum	12	Pleurotaenium trabecula	1 2	Euglena elongata	11	Eunotia ridon	12	Gomphosphaeri a lacustris
13	Gonium pectorale	13	Staurastrum gracilie			12	Fragillaria rhmboides	13	Lyngbya spiralis
14	Hydrodictyon reticulatum	14	Staurastrum paradoxum			13	Fragillaria vaucherias	14	Merismopedia glauca
15	Microspora mononucleata	15	Sphaerozosma granulatum			14	Fragillaria construens	15	Merismopedia punctata
16	Microspora bunucleata					15	Gomphonema acuminatum	16	Merismopedia tennuissima
17	Mougeotia scalaris					16	Gomphonema olivaceum	17	Merismopedia eleganse
18	Oedogonium macrandrous					17	Gomphonema subtile	18	Microcystis aeruginosa
19	Pediastrum boryanum					18	Navicula cuspidata	19	Microcystis flos-aquae
20	Pandestrum duplex					19	Nitzschia acicularis	20	Nostoc azollae
21	Pediastrum biradiatum					20	Nitzschia apiculata	21	Nostoc commune
22	Pandorina morum					21	Nitzschia longissima	22	Oscillatoria annae
23	Protocussus viridis					22	Nitzschia palea	23	Oscillatoria limnosa
24	Scenedesmus quadricanda					23	PInnularia gibba	24	Oscillatoria princeps
25	Scedesmus dimorphus					24	Surirella ovata	25	Oscillatoria tennuis
26	Secenedesmus obliques					25	Suriella elegans	26	Phormidium kuetzing
27	Scenedesmus incrassatulus					26	Synedra ulna	27	Rivularia haematites
28	Scenedesmus opoliensis					27	Synedra capitata	28	Spirulina turpin
29	Scenedismus bijugatus					28	Tabllearia flocculosa	29	**Cyanophyceae**
30	Spirogyra occidentalis					29	Stauroneis acuta	30	Anabaena aequalis
31	Tribonema minus					30			Anabaena affinis
32	Tetraspora gelitinosa						**Centrals Diatom**	31	Anacystis cyanea
33	Ulotrix zonata					31	Aulacoseir aislandica	32	Aphonacap samontana
34	Ulothrix aequalis					32	Actinocyclus normanii	33	Aphanizomenon flos-aquae
35	Volvox tertius					33	Cheatocert osabnormis	34	Arthospir amaxima
36	Volvox aureus					34	Coscinodiscus granii	35	Chrococcus turgidus
37	Zygonema spiralis					35	Cyclotella catenata	36	Chroococc usminor
						36	Cyclotella striata	37	Chroococcus minutus

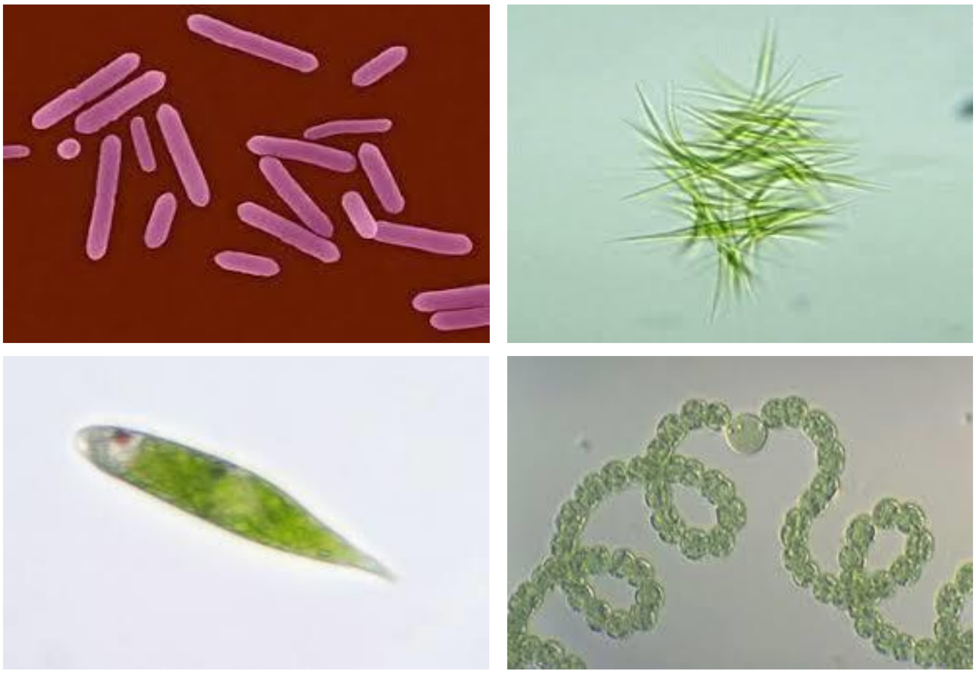


Figure 10.23: Identified planktons

Table 10.3 (b):Common Identified Zooplankton in 12 Ponds

SN	**Rotifera**	SN	**B Cladocerans**	SN	**Copepods**
1	*Asplanchna priodonta*	1	*Alone affinis*	1	*Cyclops agilis*
2	*Brachinus quadrientata*	2	*Argulis japonicuc*	2	*Cyclops viridis*
3	*Brachionus calcifloris*	3	*Bosmina logirotris*	3	*Diaptomus articus*
4	*Epiphanes senta*	4	*Daphnia megna*	4	*Eucyclopes macrurus*
5	*Euchlanis dilatata*	5	*Moina affinis*		
6	*Filinia logiseta*	6	*Monostyla clostocera*		
7	*Keratella canadensis*				
8	*Keratella cochlearis*				
9	*Keratella quadrata*				
10	*Monas vivipara*				
11	*Philodina paradoxux*				
12	*Polyartha vulgaris*				
13	*Trichocera agnatha*				

The details of Identified Phyto- and Zooplankton in Ponds are given in ANNEXURE-III.

10.4 Impact of Rejuvenation Activities on Pond Water Quality

The aquatic ecosystem is dependent on the water quality and biological diversity of the water resource. Accordingly, the water quality and trophic state index was determined before and after rejuvenation work for all the ponds. The major parameters depicting the pond health are presented in Table 10.5. The samples were collected from the ponds during 2017 and 2020. pH of ponds in 2017 ranged from 7.2 to 9.3 with average value 7.8±0.16 and in 2020, it ranged from 7.1 to 8.4 with average value 7.8±0.17. Reduction in pH was observed for most of the pond water samples and this may be due to decrease in the phytoplankton in the ponds. The electrical conductivity of the pond water samples varied from 1303 to 2280 µS/cm in year 2017 and 656 to 2650 µS/cm in the year 2020. In the year 2017 TDS value was observed in the range of 810 to 1306 mg/l and in year 2020 TDS ranged from 424.3 to 1696 mg/l. TDS and conductivity signify the presence of dissolved salts in the water and no specific impact was visible. Dissolve Oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD) are indicators of pollution status of the water body. For a healthy water body, DO should be high near saturation level and BOD values should be less than 3 mg/l. The average DO, BOD and COD of pond water samples in 2017 was 0.55±0.30 (range: non detectable - 3.1 mg/l), 51±6.1 (range: 16 - 90 mg/l), and 184±25.6 (range: 56 – 380 mg/l) respectively. In 20202, the average DO, BOD and COD values were 3.01±0.86 (range: non detectable – 8.9 mg/l), 71.7±20.0 (range: 9 - 200 mg/l), and 254.2±68.7 (range: 40 – 680 mg/l) respectively. Improvement in DO values and reduction in BOD values was observed for most of the ponds after rejuvenation. Further, the high BOD values are due to the influent BOD concentration and requiring treatment before entering the pond. Significant reduction in coliforms were observed for most of the ponds after rejuvenation activity.

Further, eutrophic status of the ponds, defining the overall health of water body, was computed from the nutrient levels in the pond water (Table 10.4). The CTSI values in 2017 ranged from 110 to 146 (Average value: 117.8±2.91) indication hypereutrophic condition. The condition changed to eutrophic status with average TSI value 82.8.8±2.69 (Range: 73 – 94). The change is eutrophic status is due to removal of organic and nutrient rich sludge accumulated at the bottom of the ponds. It is desired to have oligotrophic or at least mesotrophic status but was not achieved for the rejuvenated as most of the ponds are receiving untreated sewage rich in nutrients and organics from the habitation.

The high organics and nutrients in the pond water may be also attributed to the dumping of solid wastes line cow dung, household waste, etc., in the vicinity of ponds which get washed in the pond during rain spells. Therefore, apart from the infrastructure, awareness regarding cleanliness around pond among villagers is also the need of the hour to protect these water bodies.

Table 10.4: Trophic Status of Ponds Before and After Rejuvenation

Village ID	Village Name	TP (mg/l) 2017	TP (mg/l) 2020	TN (mg/l) 2017	TN (mg/l) 2020	TN/TP (2017)	TN/TP (2020)	Composite TSI (CTSI) (2017)	Trophic Status as per Carlson's Index (2017)	Composite TSI (CTSI) (2020)	Trophic Status as per Carlson's Index (2020)
ME - 1	Pavli Khas	29.5	2.336	410	61.05	13.9	26.1	146	Hyper Eutrophic	73	Eutrophic
ME - 2	Siwaya Jamalullapur	1.98	1.982	502	106.3	253.5	53.6	128	Hyper Eutrophic	75	Eutrophic
MN- 1	Bhora Kalan	4.29	4.491	412	45.18	96.0	10.0	111	Hyper Eutrophic	81	Eutrophic
MN - 2	Bhora Khurd - 1	6.24	7.031	416	35.31	66.6	5.0	116	Hyper Eutrophic	85	Eutrophic
MN - 3	Mohammadpur Madan	3.2	-	474	-	148.1	-	111	Hyper Eutrophic	-	-
MN - 4	Biral	13.92	9.848	512	42.6	36.7	4.3	115	Hyper Eutrophic	91	Eutrophic
MN - 5	Itawa -2	6.98	-	432	-	61.8	-	116	Hyper Eutrophic	-	-
MN - 6	Bhora Khurd - 2	5.23	4.553	433	15.43	82.7	3.3	112	Hyper Eutrophic	73	Eutrophic
MN - 7	Roni Hazipur	28.09	8.388	452	51.74	16.0	6.1	118	Hyper Eutrophic	91	Eutrophic
MN - 8	Antwara	13.77	4.864	514	44.84	37.3	9.2	115	Hyper Eutrophic	82	Eutrophic
MN - 9	Munnawarpur Kalan	30	8.128	487	93.9	16.2	11.5	110	Hyper Eutrophic	94	Eutrophic
MN - 10	Itawa - 1	4.49	-	426	-	94.8	-	115	Hyper Eutrophic	-	-

Table 10.5: Water Quality Parameters Before and After Rejuvenation of Ponds

Village ID	Before Rejuvenation (June, 2017)									After Rejuvenation (January, 2020)								
	pH	EC (µS/cm)	TDS (mg/l)	DO (mg/l)	COD (mg/l)	BOD (mg/l)	TC (MPN/100 ml)	E.coli (MPN/100 ml)	SAR	pH	EC (µS/cm)	TDS (mg/l)	DO (mg/l)	COD (mg/l)	BOD (mg/l)	TC (MPN/100ml)	E.coli (MPN/100 ml)	SAR
ME - 1	8.1	1647	810	Nil	180	48	$10X10^6$	$6X10^4$	1.26	7.4	2650	1696	1.0	192	70	2613000	624000	4.07
ME - 2	7.7	1675	840	2.2	150	60	$210X10^6$	$10X10^4$	1.95	7.4	2240	1433.	0.8	680	200	3649000	30000	3.98
MN- 1	9.3	1303	562	Nil	102	30	$170X10^6$	$20X10^4$	5.76	7.9	894	572.1	3.7	56	30	223000	10000	3.31
MN - 2	7.6	1660	774	Nil	220	65	$200X10^6$	$20X10^4$	11.06	7.2	663	424.3	3	280	50	250000	10000	1.34
MN - 3	7.5	1483	648	0.2	56	16	$220X10^6$	$6X10^4$	9.23	-	-	-	-	-	-	-	-	-
MN - 4	8.2	1735	1154	1.1	260	70	$7x10^6$	$5X10^4$	2.14	8.0	1296	829.4	8.9	328	47	1464000	231000	5.02
MN - 5	7.7	2170	1142	Nil	220	60	$230X10^6$	$5X10^4$	6.29	-	-	-	-	-	-	-	-	-
MN - 6	7.4	1770	774	Nil	68	20	$100X10^6$	$10X10^4$	5.39	7.1	656	419.8	2.8	40	9	650000	63000	1.65
MN - 7	7.6	2280	1306	Nil	380	90	$9X10^6$	$6X10^4$	3.18	8.4	1224	783.3	3.5	120	50	63000	20000	3.69
MN - 8	7.6	1909	854	3.1	200	50	$300X10^6$	$3X10^4$	10.51	8.4	1226	784.6	0	440	140	85000	20000	3.14
MN - 9	7.4	1645	954	Nil	220	54	$6X10^6$	$2X10^4$	1.66	8.1	1571	1005	3.4	152	49	960000	20000	3.96
MN -10	7.2	1540	502	Nil	160	50	$210X10^6$	$6X10^4$	6.90	-	-	-	-	-	-	-	-	-

10.5 Soil/Sludge Sampling and Analysis

10.5.1 Physico-chemical Analysis of Sludge &Soil Samples

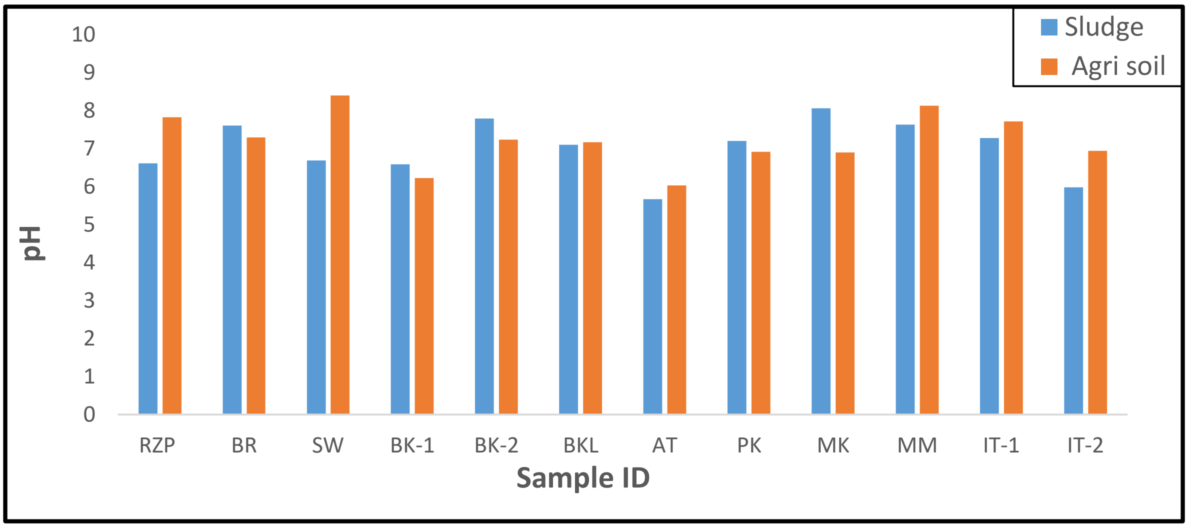
This physico-chemical study of soil is based on various parameter like pH, Electrical Conductivity (EC), Organic Carbon (OC), Available Nitrogen (N), Phosphorus (P), Potassium (K), Boron (B), zinc (Zn), copper (Cu), iron (Fe), Sulphur (S), and Manganese (Mn). Physico-chemical parameters of soil were analyzed using PUSA kit to understand the nutrients status of soil in agricultural fields near pondsites. The pond bed sludge was also characterized to understand the accumulation of trace metal and nutrients over the period of time.

pH and Electrical conductivity (EC) of pond bed sludge were observed to be in the range 5.67-7.79 and 0.407-0.648 ms/cm respectively (Table 10.6). The pH and EC of agricultural soils were in the range of 6.03-7.72 and 0.22 to 0.4 ms/cm respectively.The conductivity of the sludge samples was higher than the agricultural soils may be due to adsorbed ions.

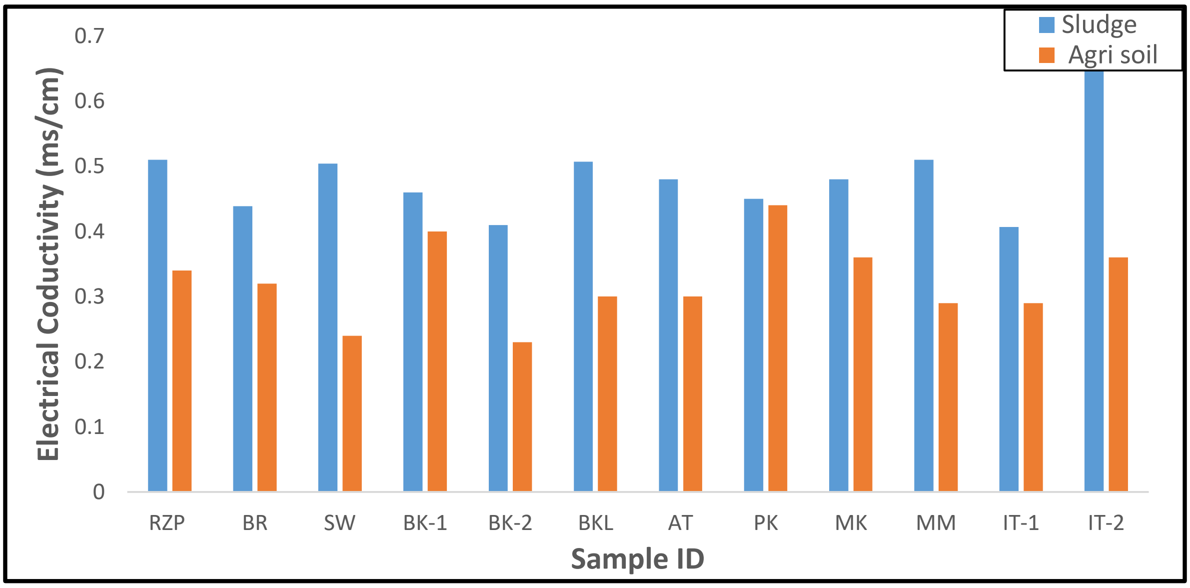
Organic carbon in the pond bed sludge and agricultural soils were in the range from0.284- 0.857% and 0.197-0.625% respectively (Table 10.7). The high organic fraction in the sludge samples were because of decomposition of organic matter and eutrophied nature of the ponds. However, the sludge will be beneficial if applied on the agricultural fields as the organic fraction will improve the moisture holding capapcity (Figure 10.24).

The phosphorous content of pond sludge and agricultural soil was in the range 44.36-162.7 kg/hac and 21.16 to 77.43 kg/hac. Also the available nitrogen content of sludge and soil ranges from 158.66-560 kg/hac and 148.3 to 338 kg/hac. The pond bed sludge was rich in nutrient as compared to agricultural soil and id applied in the field can supplement some of the nutrient deficit.

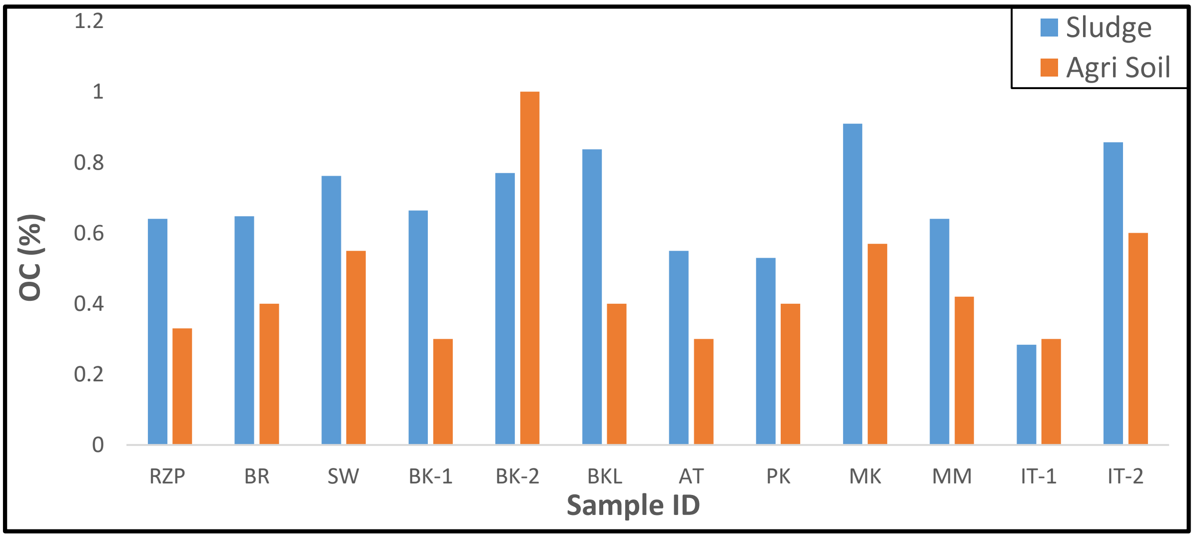
The boron, zinc, copper, iron, sulfur, manganese and potassium value in the pond bed sludge were in the range from 0.145-5.18 mg/kg, 0-20.9 mg/kg, 3.06-18.37 mg/kg, 41.02-85.83 mg/kg, 99.02-323.59 mg/kg, 12.97-94.52 mg/kg, and 0-2522.36kg/hacrespectively, and in agricultural soil the values were 0.327-2.55 mg/kg, 0-10.1 mg/kg, 1.27-4.08 mg/kg, 12.15-38.59 mg/kg, 0.27-171.29 mg/kg, 29.98-79.27 mg/kg, and 52.2-2354.1 kg/hac respectively (Figure 10.25 and Figure 10.26).



pH

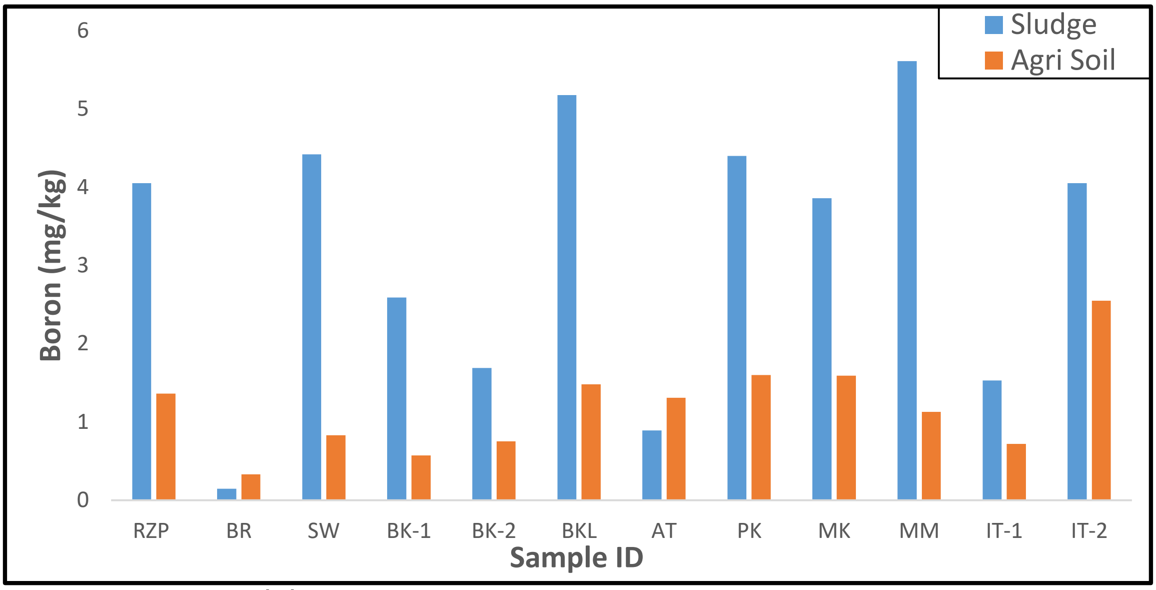


Electrical Conductivity (EC)

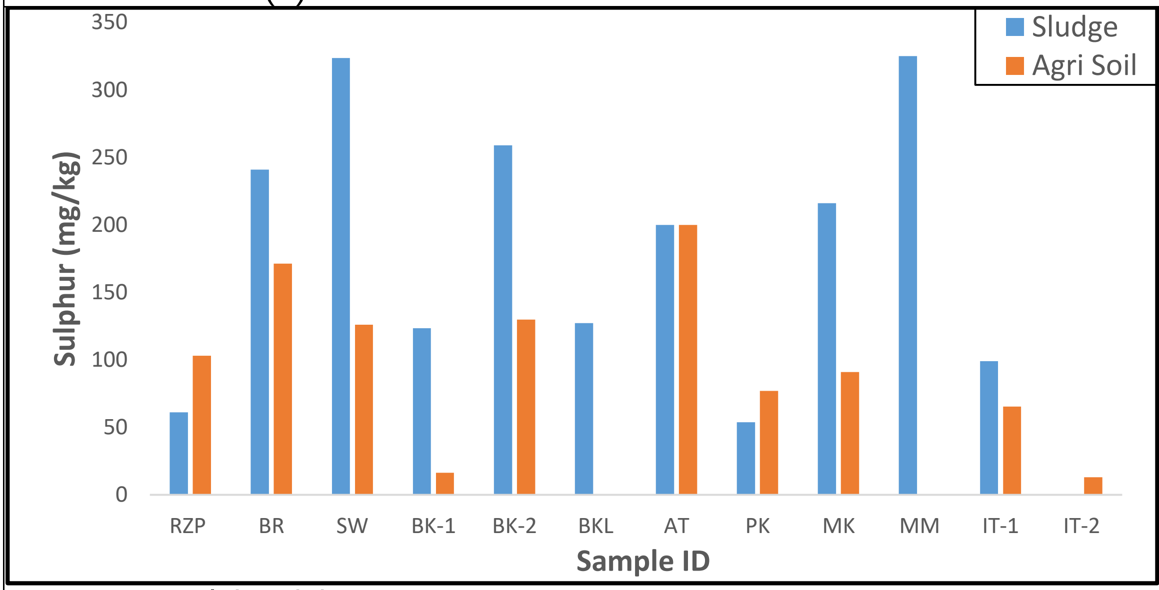


Orgaic Carbon (OC)

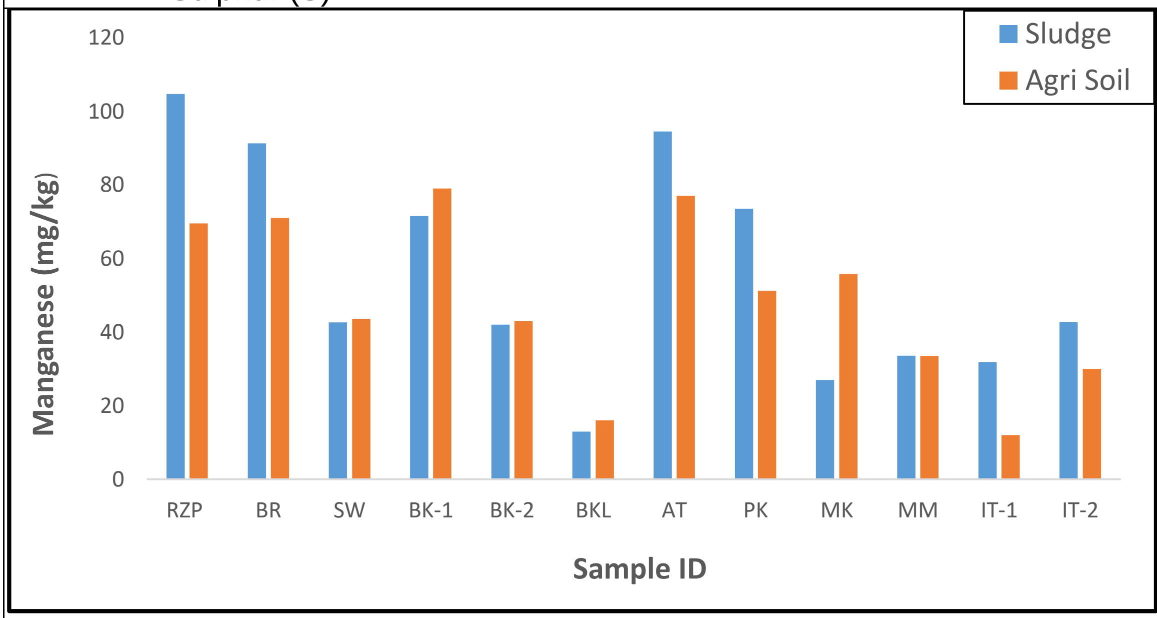
Figure 10.24: pH, EC & OC in Sludge and agricultural Soil



Boron (B)

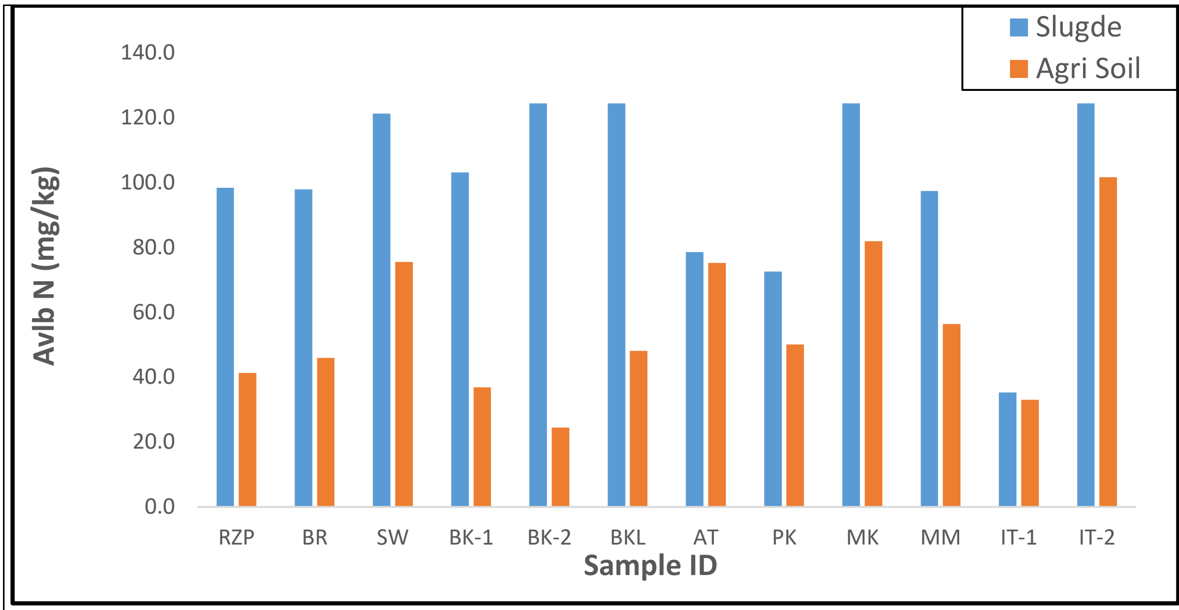


Sulphur (S)

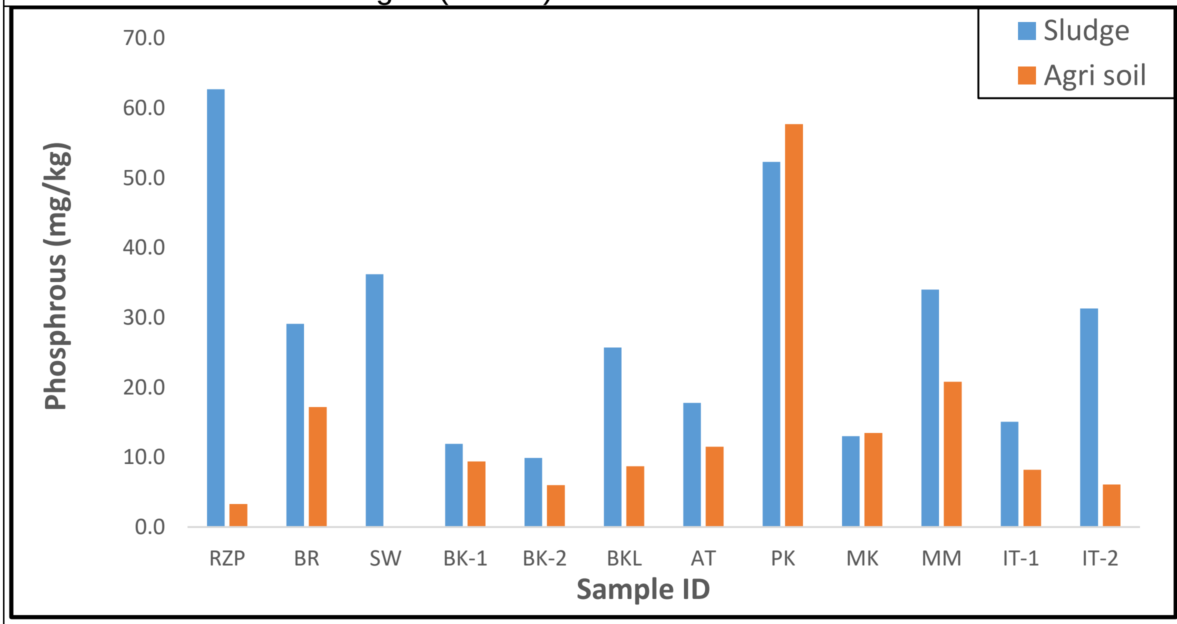


Manganese (Mn)

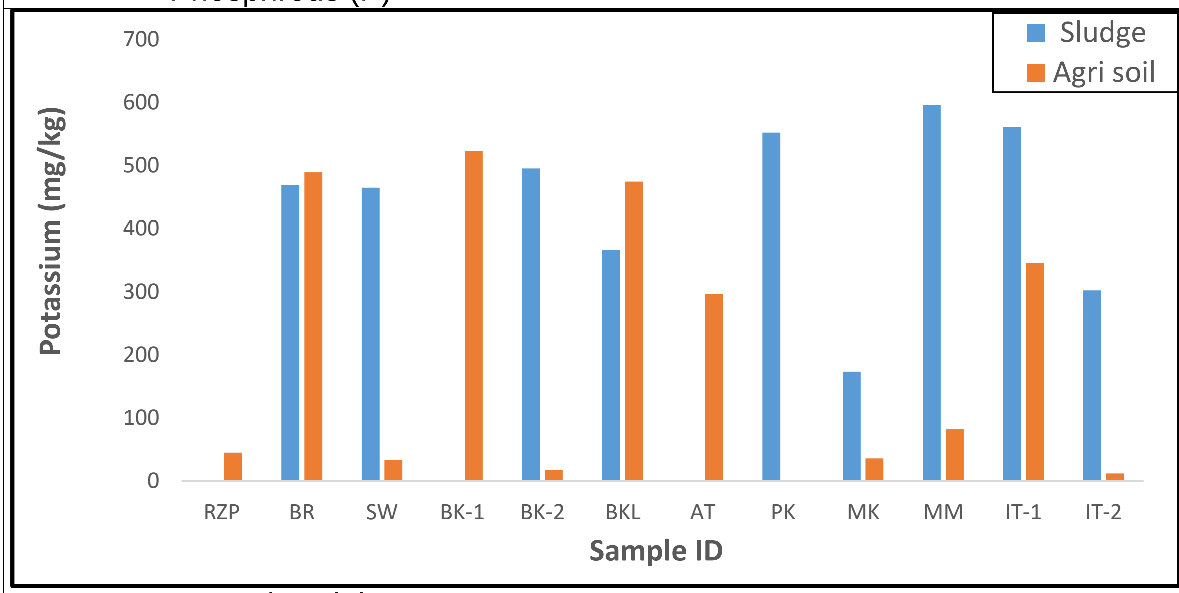
Figure 10.25: Boron, Sulphur, and Mangnese in Sludge & Agri. soil



Available Nitrogen (Avlb N)



Phosphrous (P)



Potassium (K)

Figure 10.26: Nitrogen, Phosphrous & Potassium in sludge & agri. soil

Table 10.6: Physico-chemical parameters of sludge

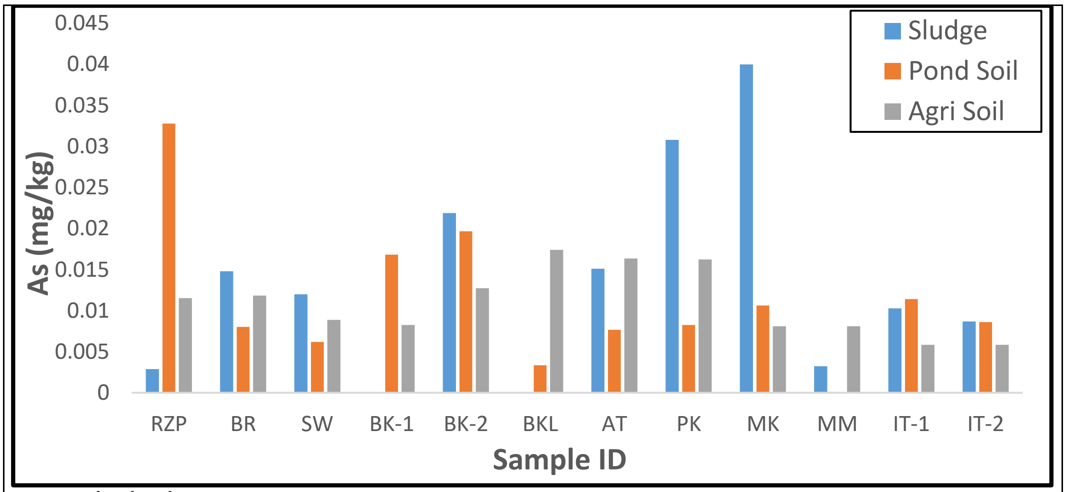
S. No.	Village Name	pH	EC (ms/cm)	OC (%)	AvlblN (kg/hac)	P (kg/hac)	Boron (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	S (mg/kg)	Mn (mg/kg)	K (kg/hac)
1	Itawa-1 Pond	7.28	0.407	0.284	158.66	68.06	1.53	2.8	18.3	45.82	99.02	31.81	2522.36
2	Antwara	5.67	0.48	0.55	353.6	80.23	0.89	4.5	6.74	43.54	199.8	94.52	-
3	Bhora Khurd-2	7.79	0.41	0.77	560	44.36	1.688	0	3.06	43.91	258.95	42.01	2227.9
4	Biral	7.61	0.439	0.648	440.66	131	0.145	40.56	4.72	-	241	91.34	2109.2
5	Itawa-2	5.98	0.648	0.857	560	140.7	4.05	1.4	4.3	45.17	-	42.72	1359.1
6	BhoraKhurd-1	6.59	0.46	0.664	464	53.63	2.592	1.63	6.05	41.02	123.4	71.51	-
7	Siwaya	6.69	0.504	0.762	545.6	162.7	4.42	20.9	3.62	85.83	323.59	42.68	2090
8	Bhora kalan	7.1	0.507	0.837	560	115.7	5.18	1.133	5.51	43.39	127.17	12.97	1650.2
9	Roni Hazipur	6.61	0.51	0.64	443	282	4.05	9.36	71.21	OR	61.1	104.7	OR
10	Pavli Khas	7.2	0.45	0.53	326	235	4.4	12	53.55	O.R.	53.86	73.54	2483
11	Munawarpur Kalan	8.06	0.48	0.91	560	58.33	3.86	16.66	3.04	20.4	216	26.95	777.9
12	Mohhamadpur Madan	7.63	0.51	0.64	438.33	153.03	5.61	8.46	7.99	104.36	324.96	33.6	2680.76

Table 10.7: Physico-chemical parameters of agricultural soil

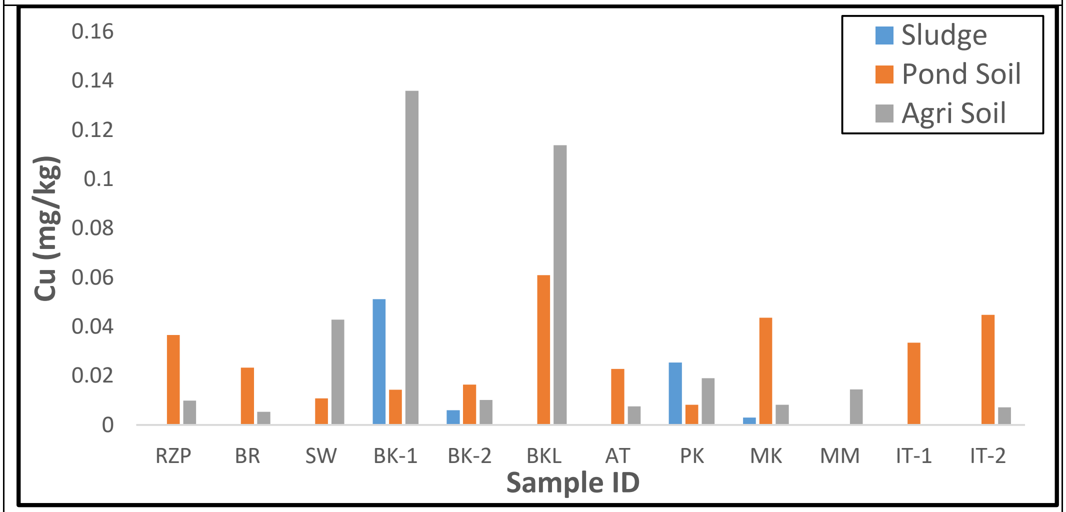
S. No.	Village Name	pH	EC (ms/cm)	OC (%)	AvlblN (kg/hac)	P (kg/hac)	Boron (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Fe (mg/kg)	S (mg/kg)	Mn (mg/kg)	K (kg/hac)
1	Itawa-1 Pond	7.72	0.29	0.3	148	36.76	0.72	0.533	1.27	12.15	65.33	12.0	1554
2	Antwara	6.03	0.30	0.3	338	51.83	1.31	1	4.08	38.59	91.76	77.0	1333
3	Bhora Khurd-2	7.24	0.23	1.0	110	26.86	0.75	0	1.32	21.23	129.77	43.0	78.0
4	Biral	7.3	0.26	0.2	127	21.16	1.36	0.633	1.49	25.22	11.65	61.0	70.0
5	Itawa-2	7.3	0.32	0.4	206	77.43	0.33	10.1	3.2	17.37	171.29	71.0	2200
6	BhoraKhurd-1	6.94	0.36	0.6	457	27.30	2.55	0	1.92	15.85	13.09	30.0	52.0
7	Siwaya	6.23	0.40	0.3	165	42.10	0.57	0	3.19	21.6	16.31	79.0	2354
8	Bhora kalan	7.17	0.30	0.4	216	39.20	1.48	0	3.26	17.24	0.27	16.0	2132
9	Roni Hazipur	7.83	0.34	0.33	186	14.7	1.36	0.43	48.08	31.36	103.02	69.54	201.6
10	Pavli Khas	6.92	0.44	0.4	225	259	1.6	0	16.53	194	77	51.23	OR
11	Munawarpur Kalan	6.9	0.36	0.57	368.33	60.9	1.59	3.56	5.82	59.97	90.97	55.77	159.16
12	Mohhamadpur Madan	8.13	0.29	0.42	254	93.6	1.13	12.06	6.25	13.97	OR	33.49	367.3

10.5.2 Trace Metals Analysis of Sludge, Pond Soil and Agricultural Soil Samples (2019)

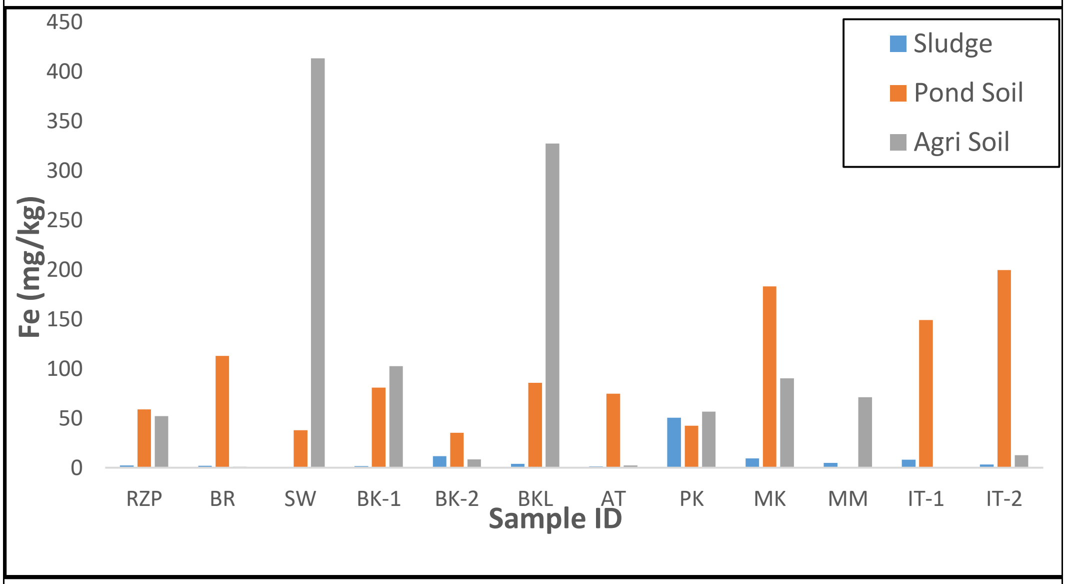
Toxic metals present in wastewater have high tendency to accumulate in sludge. In addition, as a result of various anthropogenic activities, including farming, the trace metal leach from the minerals and contaminate the water resources. Along with runoff from the catchment, the metals enter the pond and contaminate the pond water. The analysis of pond bed sludge provides and insight about the trace metals reaching the pond. Therefore, the trace metals were analyzed in the pond bed sludge, pond bed soil and agricultural soil of the study area, and high concentration of toxic metals were observed in the pond sludge and soil samples. The results of trace metals are provided in Fig. 10.27. Also, the TCLP stuby to understand the leaching of toxic metals from the sludge and soil samples to the groundwater of the area were conducted and the analysis of the leachate is under progress.



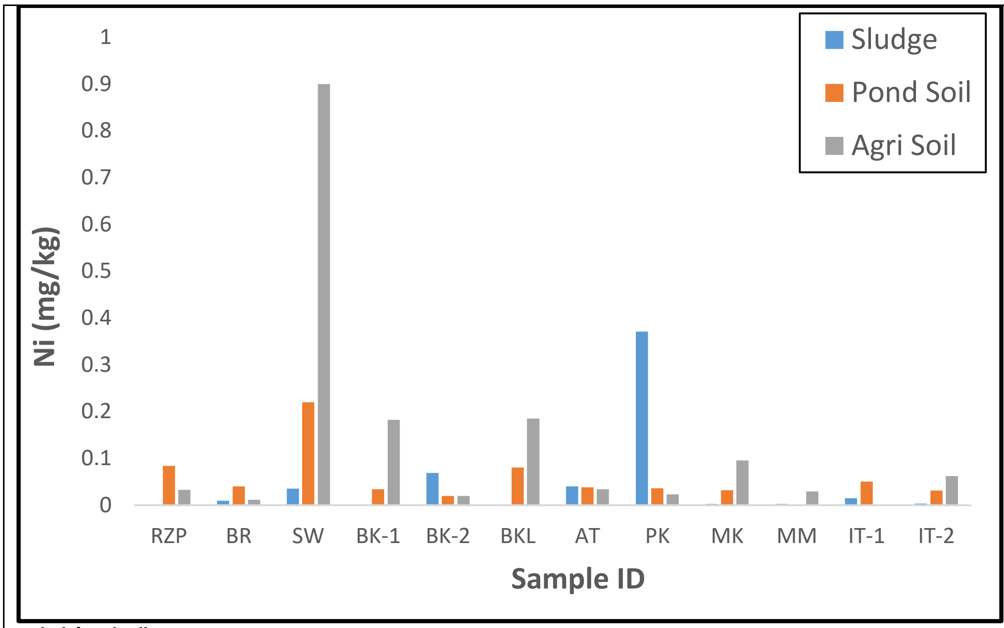
Arsenic (As)



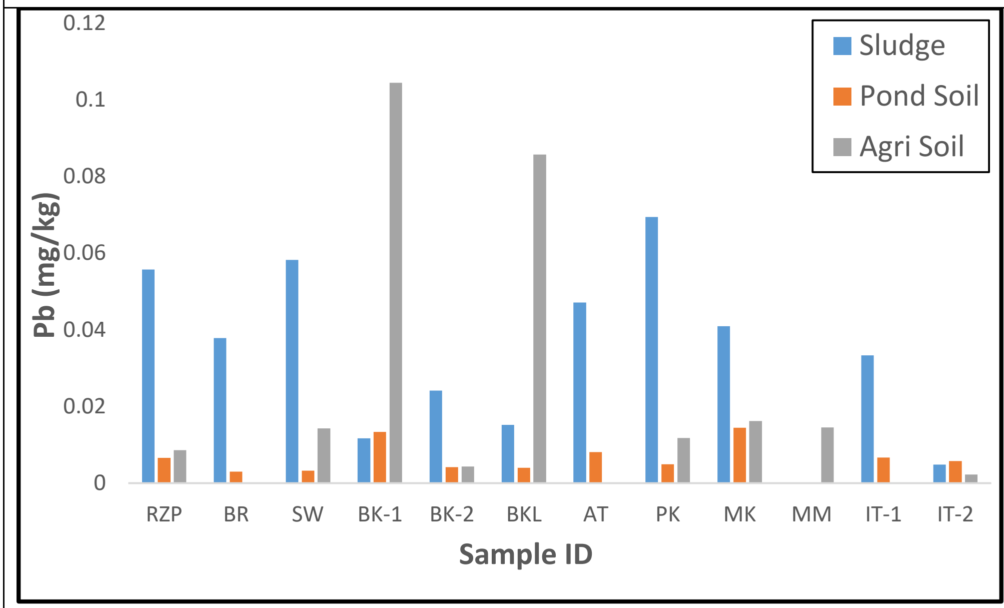
Copper (Cu)



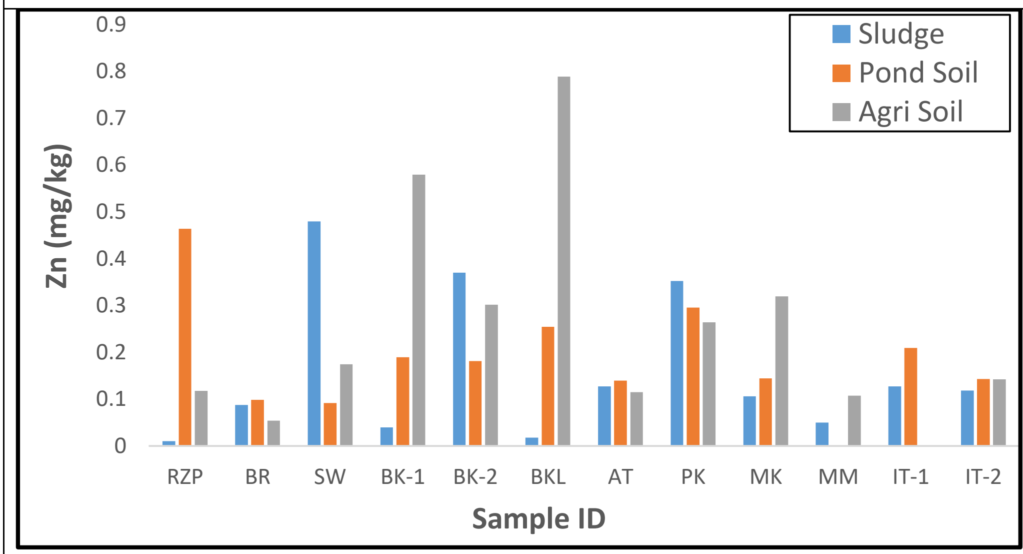
Iron (Fe)



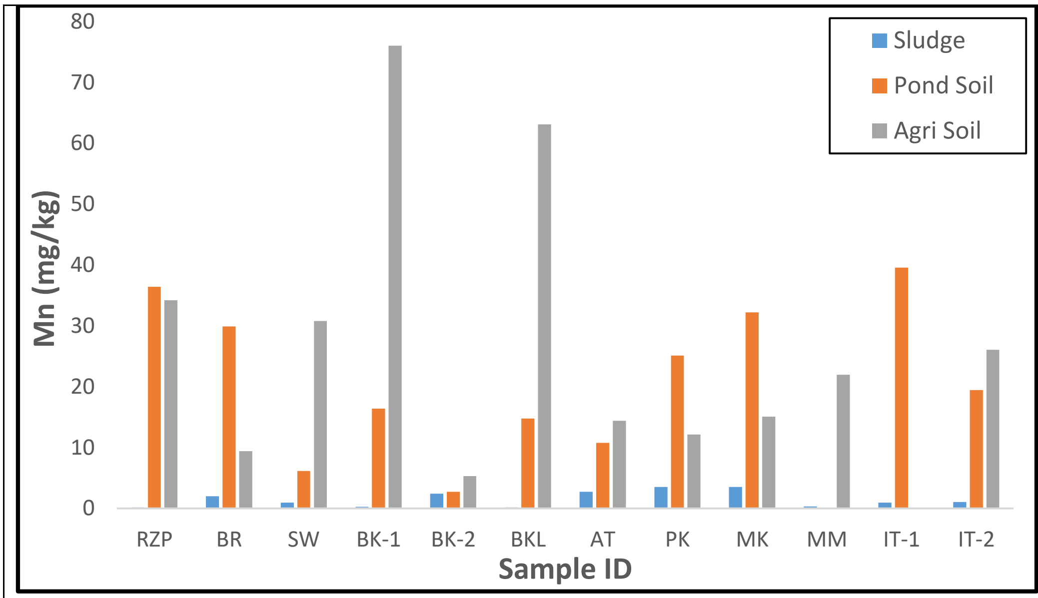
Nickle (Ni)



Lead (Pb)



Zinc (zn)



Mangnese (Mn)

Figure 10.27: Trace metals concentration in sludge, pond soil and agricultural soil

10.5.3 Permeability Tests/Analysis of Soils (Pond Beds)

Study of soil at a pond site is important to assess the suitability of pond to hold water. The soil should contain a layer of material that is impervious and thick enough toprevent excessive seepage. Clays and silty clays are excellent for this purpose; sandy and gravelly clays are usually satisfactory. Permeability is a measure of the ease in which water can flow through a soil volume.

The undisturbed soil samples were taken after de-sludging from identified ponds beds representing pond layers (0-20, 20-40, 40-60,60-80 cm) under this study. The permeability of these samples was determined in the Lab, which varies from 0.021-0.598 m/day (at 0-20 cm depth), from 0.028-4.877 m/day (at 20-40 cm depth), from 0.051-8.724 m/day (at 40-60 cm depth), from 0.007-8.453 m/day (at 60-80 cm depth), respectively. The average values of permeability vary from 0.056 to 5.491m/d in the study area (Table 10.8). A plot of average permeabilities of identified ponds (at beds) is given in Fig. 10.28. However, higher values permeability of pond beds was obtained at Munawwarpur Kala, Siwaya and Pavlikhas, which is to be correlated with soil texture and during further investigations.

Table.10.8: Average Values of Permeability and Bulk Density of Pond Beds (Depth: 0-80 cm)

Name of Pond	Av. Permeability (m/day)	Bulk density (gm/cm^3)
Biral	0.107	1.4
Anawara	0.087	1.6
Siwaya	4.661	1.5
Munawwar Pur Kala	5.491	1.5
Itawa-1	0.245	1.6
Itawa-2	0.108	1.5
Bhora Kala	0.067	1.4
Rono Hazipur	0.077	1.9
Pavlikhas	1.062	2.0
Bhora Khurd-1	0.056	1.9

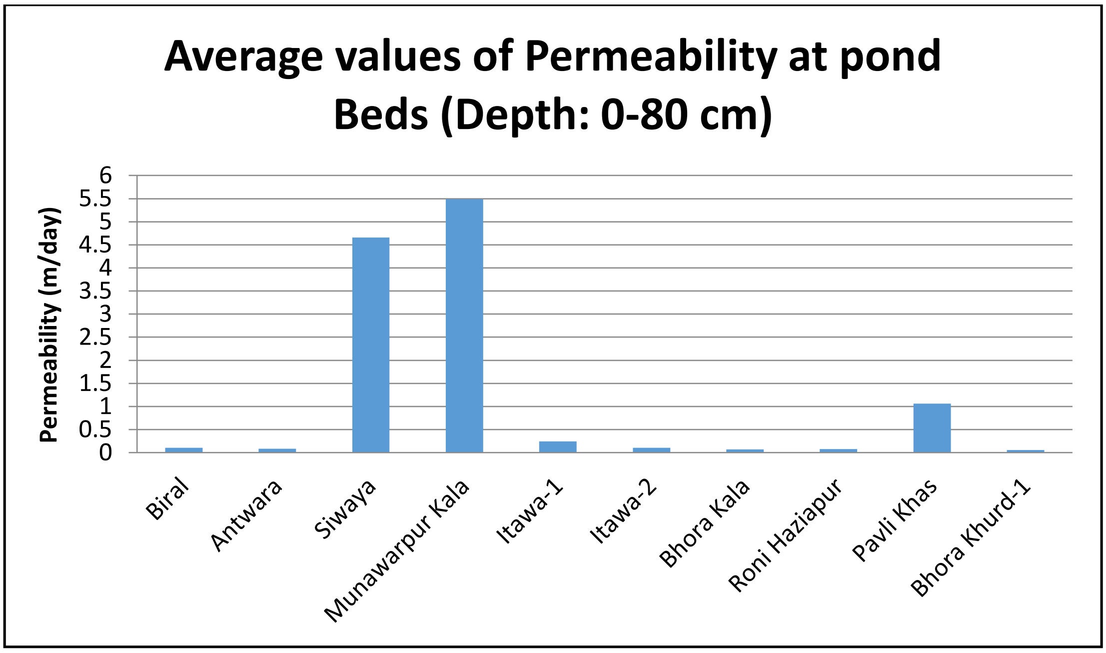


Figure 10.28: Plot of average permeabilities of identified ponds (at beds)

10.5.4 Infiltration Characteristics (Pond Beds)

Infiltration is the process by which water on the ground surface enters into the soil surface. Precipitation falling on the soil wets down and it starts penetrating into the soil. The rate at which a soil absorbs the water in a given time is called infiltration rate, and it depends on soil characteristics such as hydraulic conductivity, soil structure, vegetation cover. The infiltration plays an important role in generation of runoff volume, if infiltration rate of given soil is less than intensity of rainfall then it results in either accumulation of water on soil surface or in runoff. Typical values of hydrologic soil groups and infiltration raetes for various soils are given in Table-10.9, Table-10.10, respectively.

The infiltration tests were carried at different identified ponds after de-sludging. The plots of infiltration characteristics of pond beds are given in Fig 10.29. The final infiltration rates are given Table 10.11, which varies from 0.0 mm/h to 16.09 mm/hr. Higher values of final infiltration rates were observed at Bhora Khurd-1, Bhora Kala, Munawarpur Kala, Siwaya and Itawa-2, respectively in the study, which are to be further investigated.

Table 10.9: Hydrologic Soil Groups

Final Infiltration Rate (mm/hr)	Description	Soil Group
8-12	Lowest Runoff Potential. Includes deep sands very little silt and clay, also deep, rapidly permeable losses	A
4-8	Moderately Low Runoff Potential, Mostly sandy soilsless deep than A, and looses less deep or less aggregated than A, but the group as a whole has above infiltration after thorough wetting.	B
1-4	Moderately High Runoff Potential. Comprises shallow soils and soils containing considerably clay and colloids, though less than those of group D. The group has below average infiltration after presaturation.	C
0-1	Highest Runoff Potential. Includes mostly clays of high swelling percent, but the group also includes some shallow soils with nearly impermeable sub horizons near the surface.	D

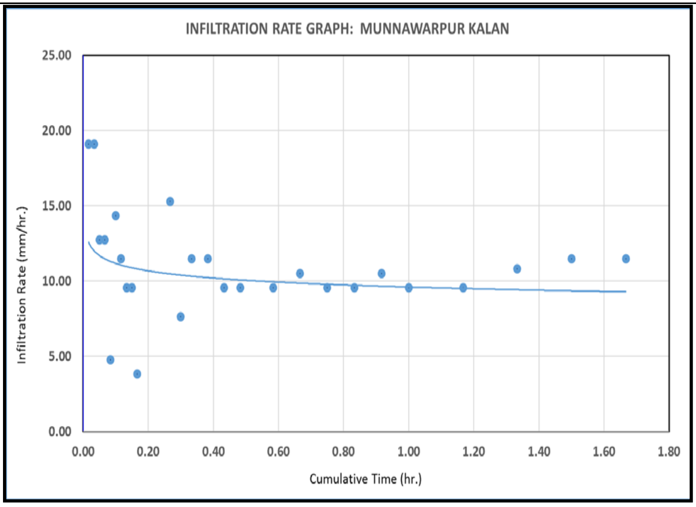
(Source: U.S.Soil Conservation Service, National Engineering Handbook, Hydrology, Section 4 and U.S Dept. Agr.ARS 41-172 (1970)

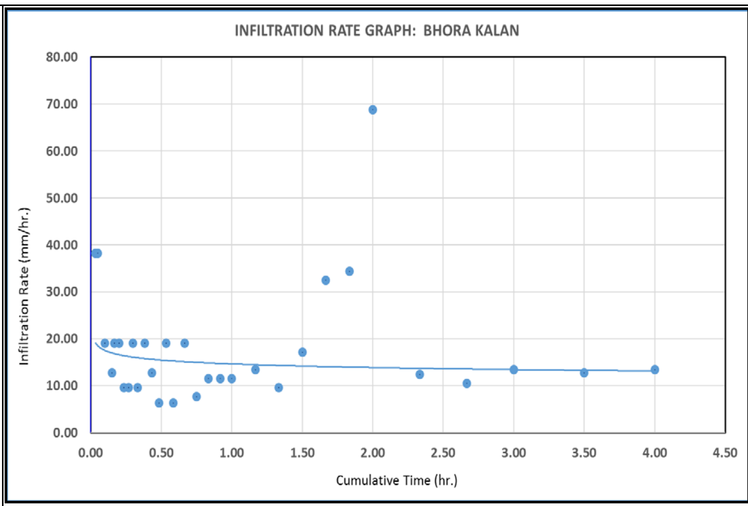
Table10.10. Infiltration Rate for Various Soil Types (Thomas et., al, 2004)

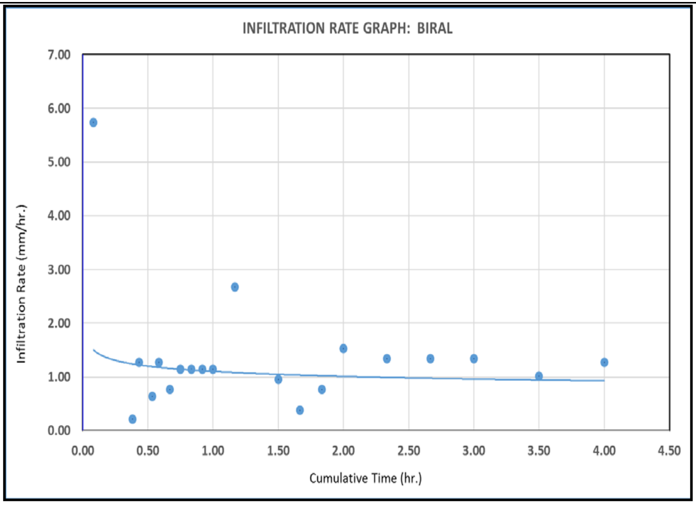
Soil Type	Infiltration Rate (mm/hr.)	Infiltration Class
Sand	>30	Very rapid
Sandy Loam	20 - 30	Moderately rapid to rapid
Loam to Silt loam	10 - 20	Moderately slow to moderately rapid
Clay Loam	5 -10	Slow to moderately slow
Clay	1 - 5	Very slow to slow

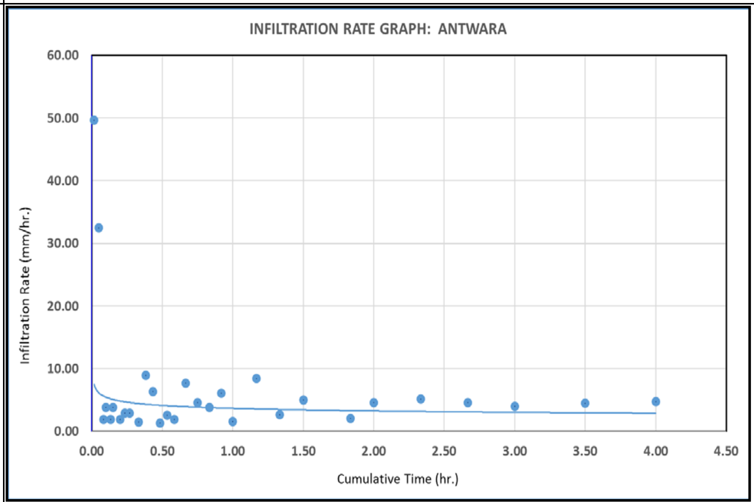
Table 10.11. Final Infiltration Rates at pond beds

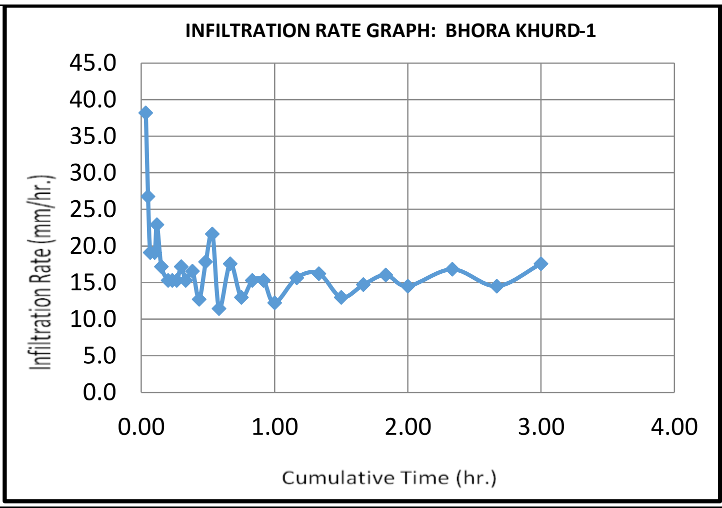
S.No	Pond Site	Final Infiltration Rates (mm/hr)	Hydrological Soil Group
1	Bhaura Kalan	13.4	A
2	Biral	1.3	C
3	Antwara	4.7	B
4	Itawa-1	0.4	D
5	Itawa-2	12.6	A
6	Bhaura Khurd-2	0.0	D
7	Munawarpur	11.5	A
8	Siwaya	12.7	A
9	Bhaura Khurd-1	16.09	-
10	Pavli khas	2.73	C
11	Roni hazipur	0.28	D

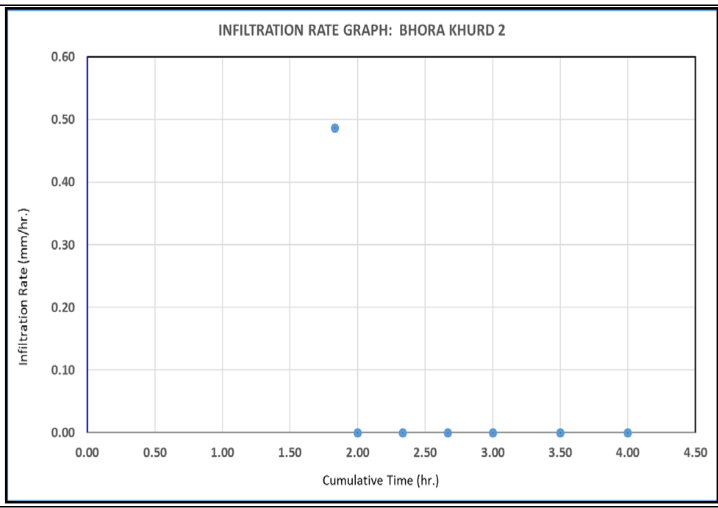

INFILTRATION RATE GRAPH: MUNNAWARPUR KALAN
Infiltration Rate (mm/hr.)
0.00
5.00
10.00
15.00
20.00
25.00
0.00 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80
Cumulative Time (hr.)


INFILTRATION RATE GRAPH: BHORA KALAN
Infiltration Rate (mm/hr.)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50
Cumulative Time (hr.)


INFILTRATION RATE GRAPH: BIRAL
Infiltration Rate (mm/hr.)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50
Cumulative Time (hr.)


INFILTRATION RATE GRAPH: ANTWARA
Infiltration Rate (mm/hr.)
0.00
10.00
20.00
30.00
40.00
50.00
60.00
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50
Cumulative Time (hr.)


INFILTRATION RATE GRAPH: BHORA KHURD-1
Infiltration Rate (mm/hr.)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
0.00 1.00 2.00 3.00 4.00
Cumulative Time (hr.)


INFILTRATION RATE GRAPH: BHORA KHURD 2
Infiltration Rate (mm/hr.)
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50
Cumulative Time (hr.)

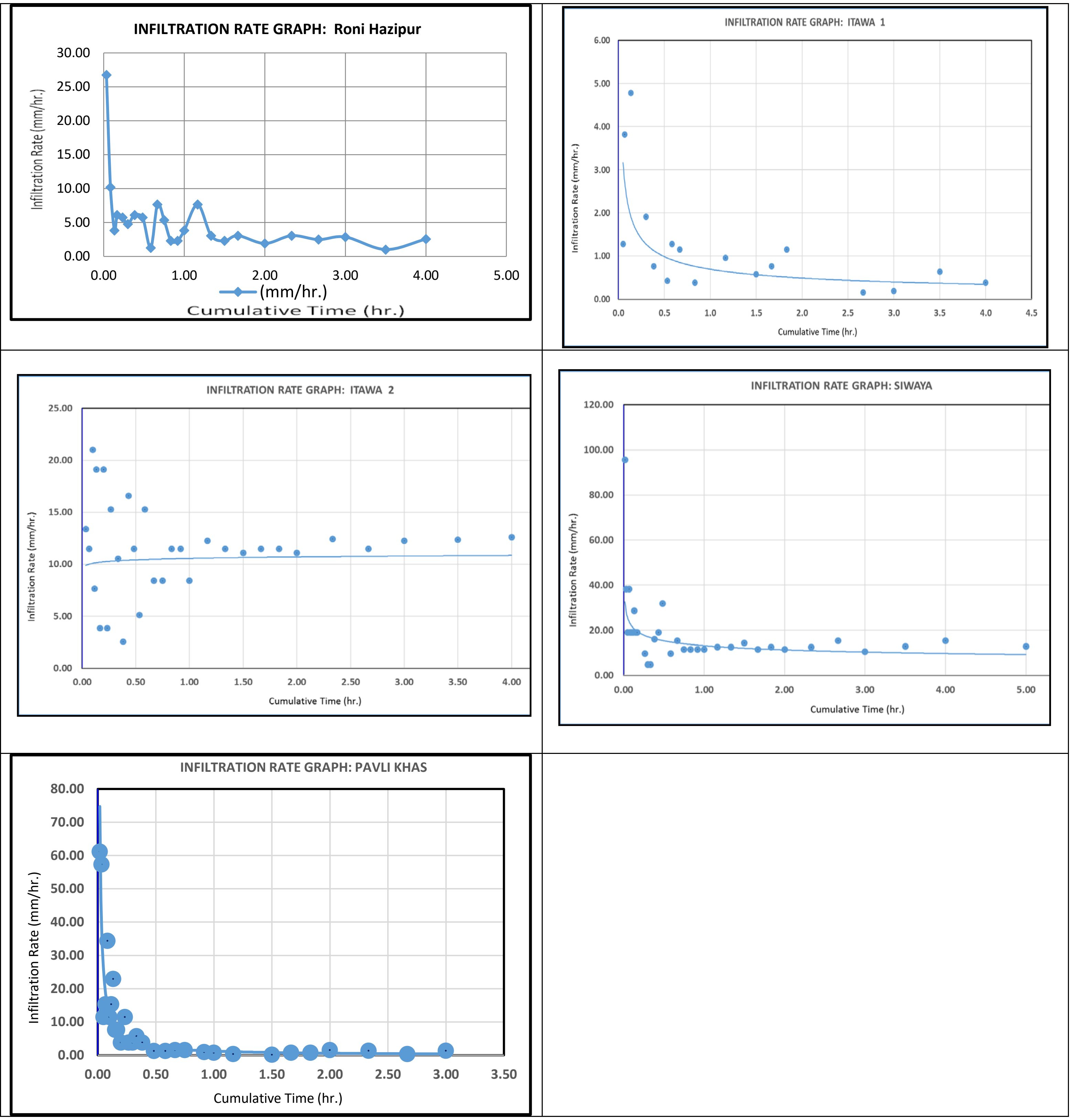


Figure 10.29: Infiltration rate at pond sites

The field photographs of various visits (Water Quality, GWL, Collection of Sludge/Soil Samples, Infiltration Tests, Visit of Director-R&D, MoWR) are given in Annexures- IV & V.

11.0 CONCLUSION

This action research project was awarded by DoWR, RD & GR (MoJ) GOI with the primary objective of rejuvenation of 12 identified village ponds (Munnawarpur Kalan, Antwara, Siwaya, Pavli Khas, Roni Hazipur, Bhora Khurd-1 & 2, Bhoran Kalan, Itawa-1 & 2 and Mohammadpur Madan) in Muzaffarnagar & Meerut Districts of Western UP.

The pond rejuvenation work involves two broad components: civil work component and R&D component. Improvement of physical conditions (e.g. deweeding, desludging, improvement of inlets, outlets & embankment) comprise the former, and instalment of wastewater treatment technology along with trophic status assessment (both pre- and post intervention) comprise the latter component. In this project, both components were attempted.

With extensive field investigations and laboratory analysis, the baseline data of pond physical characteristics, pond water quality, wastewater quality, and groundwater quality (in nearby hand pumps) was prepared. Various field investigations were carried out to assess the pre-rejuvenation condition of ponds in terms of water quality, wastewater quality and groundwater quality and level in adjacent handpumps. After removal of sludge, infiltration tests were conducted and soil samples collected from the pond beds and nearby fields for analysis of permeability values and soil texture.Field and laboratory investigations were then carried out during the rejuvenation stage (sampling of pond sludge, soils, permeability and infiltration tests on pond beds, bulk density and soil texture).

Using the baseline physico-chemical and biological data collected in the project, the ecological health and trophic status of the ponds was estimated in terms of various indices (e.g. TSI, Nygaard's Algal Index, Shannon-Weaver Diversity Index). Correlation analysis between physic-chemical and biological parameters was carried out to identify the driving factors responsible for eutrophication of the ponds. Landuse mapping around pond sites was conducted to aid in the planning of the use of treated pond water.

The selected ponds at the time of initiating the project were heavily infested with weeds and were almost completely filled with sludge. As a result, frequent flooding and water logging conditions prevailed at these sites. Deweeding and desludging has not only enhanced the storage capacity but also led to improving the pond water quality. Local villagers have confirmed this aspect and appreciated the project for this achievement.

Groundwater level was also measured in the year 2017 & 2019. Groundwater level ranged from 3.87m to 37.4m (2017) and 3.81m to 34.2m (2019).Groundwater quality test was conducted to assess its suitability for drinking purpose, and to study the impact of ponds on drinking water quality of the surrounding area. Total 48 samples of pond, wastewater and ground water samples (Year 2017) and 33 ground water samples (Year 2019) samples were collected and analyzed for physical-chemical, microbiological parameters and trace metals.Results of the study showed that total dissolved solid of 62% ground water samples were above the permissible limit as prescribed by BIS (2012). Turbidity and calcium of all ground water samples were above the permissible limit i.e., 01 NTU and 75 mg/l. Fluoride concentration of approx. 23% water samples tested were above the acceptable limit i.e., 1.0 mg/l (IS 10500:2012). Total Hardness and Total alkalinity of all water samples above the permissible limit i.e., 200 mg/l respectively.

Infiltration test were also conducted and results of infiltration rate of ponds ranged from 0.28 to 16.09 mm/hr. minimum in Roni Hazipur pond and maximum infiltration in Bhora Khurd Pond-1. PUSA kit analysis of soil samples were conducted and on the basis of the results soil health card prepared for the different crops.

12.0 RECOMMENDATIONS

1. Subsequent to the filling of ponds during the last monsoon period (Jun-Oct 2019), weeds reappeared in some of the ponds as noticed during the recent visit. A variety of other solid waste is being dumped into these ponds, and the local Gram Panchayats (GPs) are unable to ensure mitigating measures for maintenance of the ponds. In order to ensure sustained functioning of the rejuvenated ponds, the local GPs have to take a proactive role in preventing the dumping of solid waste material in ponds and in regular cleaning of the inlet channels. Some relevant do's and don't's for the GPs in form of a Standard Operating Procedure (SOP) are as follows:

    - The ponds and its surrounding should be kept clean and disposal of solid waste in and around the ponds should be avoided.
    - The inlet drains / chamber to the ponds should be regularly cleaned, as and when required.
    - The water hyacinth grows in the water bodies with high nutrient load, and all the ponds under this project are receiving the domestic wastewater emanating from the village, due to which the appearance of these aquatic plants is normally expected. However, these should be removed immediately, if observed.
    - Regular maintenance of rejuvenated ponds is required to remove unwanted weeds (e.g. water hyacinth), to clear choking of inlet channels with solid waste, pruning of wetland plants, etc.
    - The GP should try to prevent any encroachment of ponds in future.

2. The Jal Shakti Abhiyan has highlighted the importance of restoring village ponds under its second area of intervention i.e. renovation of traditional water bodies/tanks. Also, some State Governments have initiated focused programmes for rejuvenation of ponds. Sound interventions on scientific basis are required to achieve success in this endeavour. Based on the findings of this project and a DST-funded networking project, DST (GoI) and NIH are planning to bring out Guidelines on S&T Interventions for Pond Rejuvenation in India.

The details of visit report of NIH & NPCC (Duration of Visit: 27-29 November, 2019) are given Annexure-VI.

13.0 FIELD TEST CONDUCTED

The first set of field investigations for pond water and groundwater sampling (and level measurement) was conducted in May-July 2017, followed by sludge and soil sampling in Oct 2018- Jan 2019, and the second set of groundwater sampling (and level measurement) was conducted in Apr-May 2019. The details of field investigations are given below Table 13.1 and Table 13.2:

Table 13.1. Field Visit in the Year 2017

Field Visit in the Year 2017					
S.No	**Village name**		**Ground Water Level Measurement**	**Ground Water Sample Collection**	**Pond Water Sample Collection**
A	**MUZAFFARNAGAR**				
1	Mohammadpur Madan - 2	Baghra	**13-07-2017**		
2	Bhora Kalan	Shahpur	14-07-2017		
3	Bhora khurd-1	Shahpur	14-07-2017		
4	Bhora khurd-2	Shahpur			
5	Itawa-1	Budhana	26-07-2017		
6	Itawa-2	Budhana			
7	Biral	Budhana	26-07-2017		
8	Munnawarpur Kalan	khatauli	11-07-2017		
9	Roni Hazipur	Charthawal	13-07-2017		
10	Antwara	Khatauli	11-07-2017		
B	**MEERUT**				
1	Siwaya	Shiwaya	12-07-2017		
2	Pavli khas	Pavlikhas	12-07-2017		

Table 13.2. Field Investigations/R&D WORK (Year 2019)

S.No	**Village name**		**Field Investigations/R&D WORK (Year 2019)**						
			Sludge sample	**Soil sample**		**Infiltration Test**	**Ground Water Level Measurement**	**Ground Water Sample**	**Agri. soil sample**
				Disturbed	**Un-disturbed**				
A	**MUZAFFARNAGAR**								
1	Mohammadpur Madan - 2	Baghra	23/4/2019	water available in pond	water available in pond	water available in pond	23/4/2019	23/4/2019	23/4/2019
2	Bhora Kalan	Shahpur	17/10/2018	17/10/2018	17/10/2018	4/12/2018	4/12/2018	4/12/2018	17/10/2018
3	Bhora khurd-1	Shahpur	11/1/2019	11/1/2019	25/4/2019	25/4/2019	25/4/2019	25/4/2019	11/1/2019
4	Bhora khurd-2	Shahpur	11/1/2019	11/1/2019	11/1/2019	11/1/2019	-	-	11/1/2019
5	Itawa-1	Budhana	9/1/2019	9/1/2019	9/1/2019	9/1/2019	24/5/2019	24/5/2019	9/1/2019
6	Itawa-2	Budhana	8/1/2019	8/1/2019	8/1/2019	8/1/2019	24/5/2019	24/5/2019	8/1/2019
7	Biral	Budhana	3/1/2019	3/1/2019	3/1/2019	3/1/2019	22/5/2019	22/5/2019	3/1/2019
8	**Munnawarpur Kalan**	**khatauli**	17/10/2018	17/10/2018	17/10/2018	17/10/2018	15/5/2019	15/5/2019	17/10/2018
9	Roni Hazipur	Charthawal	24/4/2019	24/4/2019	24/4/2019	24/4/2019	24/4/2019	24/4/2019	24/4/2019
10	Antwara	Khatauli	7/1/2019	7/1/2019	7/1/2019	7/1/2019	15/5/2019	15/5/2019	7/1/2019
B	**MEERUT**								
1	Siwaya	Shiwaya	15/10/2018	15/10/2018	15/10/2018	15/10/2018	23/5/2019	23/5/2019	23/5/2019
2	Pavli khas	Pavlikhas	18/3/2019	18/3/2019	18/3/2019	18/3/2019	24/5/2019	24/5/2019	18/3/2019

14.0 SOFTWARE GENERATED, If Any

NA

15.0 POSSIBLITIES OF ANY PATENT/ COPYRIGHT

Few research papers prepared for publication in reputed journals.

16.0 SUGGESTIONS FOR FURTHER WORK

On the basis of findings of the study, some suggestions are made as follows:

1) Since ponds are the lifeline of Indian villages, these should be protected and rejuvenated as an instrument of water security.Such rejuvenated ponds could also be used as livelihood opportunity for local community.
2) Huge quantity of wastewaterentering into rural and urban ponds need to be utilized after treatment with appropriate Nature Based Solutions (NBS), such as Constructed Wetlands and Floating Wetlands, for limited irrigation purposes and for recharging of groundwater.
3) Regular monitoring of water quality parameters of ponds and adjacent hand pumps (GW) is required for the assessment of impact of rejuvenation of ponds.
4) Long-term monitoring of phytoplanktons and zooplankton composition and abundance is required to formulate the rejuvenation strategies of such village ponds in India.

17.0 REFERENCES

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ANNEXURE-I: Sanction Letter of Project

FAX NO. :01123354496   05 May 2017 17:55 P 3

Government of India
Ministry of Water Resources, RD&GR
PP Wing - R&D Division
1st Floor, Wing 4, West Block–I, R.K. Puram, New Delhi-110066
Telephone : 011- 29583482 FAX No. 29583647 E-mail : watrnd-mowr@nic.in.

No. 15/1/2017-R&D/ 638-648   Dated: April 13 , 2017

Administrative Approval

Subject: **Sanction of new proposal by NIH on *'Action Research on IWRM Plan for water security in identified villages of Western UP'***

The Administrative Approval of the Ministry of Water Resources, RD&GR is hereby conveyed for taking up the action research scheme "Action Research on IWRM Plan for water security in identified villages of Western UP" under R&D programme of MoWR, RD&GR at a total estimated cost of Rs.8,30,00,000/- (Rupees eight crore thirty lakh only) as per details given below:

Name of the Institutions	: NIH, Roorkee
Name of the PI	: Dr. V.C. Goyal, Scientist "G" and Head, Research Management and Outreach Division
Estimated Cost	: 830 Lakhs
Duration of the scheme	: 36 Months

2. The study would be implemented within overall ambit of R&D Guidelines of MoWR, RD&GR and there should be no duplicity with any other scheme/project of GoI/State government/any other source.
3. The scheme will be implemented under the supervision of Indian National Committee on Surface Water (INCSW), which will also be responsible for coordination and monitoring of both physical and financial progress of the scheme.
4. The expenditure involved will be met from the sanctioned Grant-in-Aid released by the Government of India in installments.
5. The above sanction of the scheme is subject to the conditions of Grants-in-Aid of Government of India as enclosed at Annexure-1 *(appendix 4 of R&D guidelines)*. The emoluments and other conditions of services for research personnel shall be in accordance to the guidelines at Annexure-2 *(appendix 2 of R&D guidelines)*. The release of the 1st installment will be made after the acceptance of above conditions by the PI/Co-PI duly forwarded by Head of the Institute to INCSW.
6. The expenditure would be limited to the sanctioned or actual cost whichever is lower.
7. The approval of competent authority as per latest R&D guidelines would be taken by the PI/Co-PIs for any time extension, revision of cost or any other adjustment of components etc.
8. The funds will be transferred through PFMS for which duly filled bank mandate form and agency details in the prescribed pro-forma *(copy enclosed)* along with a copy of cancelled cheque of the bank accounts in which the funds are to be credited will be submitted by the Lead PI and all Co-PI.
9. INCSW to ensure the disbursement of the fellowship by the Institute to JRF & SRF for the MoWR,RD&GR funded project in AADHAR linked Bank Accounts as per latest Direct Benefi Transfer (DBT) Guidelines.
10. In relation to any dispute, Secretary (WR, RD&GR) or the authority authorized by him would be final authority and such dispute resolution meeting shall take place only at Delhi and no TA/DA shall be admissible for such travel to the Institute/agency.
11. This issues with the concurrence of the Integrated Finance Division, MoWR, RD&GR vide its Diary dated 11.04.17

Encls:
i. Annexure 1 & 2
ii. Annexure 3: Proforma for endorsement letter by Head of Institute.
iii. Proforma for mandate form and agency details.

(S.K. Chaturvedi
Director (R&D

To:
1. D.D.O (Cash), MoWR,RD&GR, Shastri Bhawan, New Delhi –110001.

Contd. on page 2,

2. Pay & Accounts Officer (Sectt.), MoWR,RD&GR, 'E' Block, Shastri Bhawan, New Delhi-110001
3. Member secretary(INCSW) and Director, INCSW-Sectt., CWC, Room no. 412(S), Sewa Bhawan, R.K. Puram, New Delhi.
4. Dr. V.C. Goyal, Scientist "G" and Head, Research Management and Outreach Division, NIH Roorkee.
5. Director, NIH Roorkee.

Copy to:

1. PPS to Hon'ble Minister of State (MoWR,RD&GR), Shram Shakti Bhawan, New Delhi-110001
2. Joint Secretary (PP), MoWR,RD&GR, Shram Shakti Bhawan, New Delhi-110001
3. Controller of Accounts, MoWR,RD&GR, 'E' Block, Shastri Bhawan, New Delhi-110001.
4. Internal Audit Wing, PAO, MoWR,RD&GR, 'E' Block, Shastri Bhawan, New Delhi-110001.
5. Principal Director of Audit, Economics & Services Ministries, AGCR Building, Indraprastha Estate, New Delhi-110002.
6. B&T Section, MoWR,RD&GR, Shram Shakti Bhawan, New Delhi-110001.
7. Finance Desk, MoWR,RD&GR, Shram Shakti Bhawan, New Delhi-110001.
8. Guard File, R&D Division, MoWR,RD&GR.

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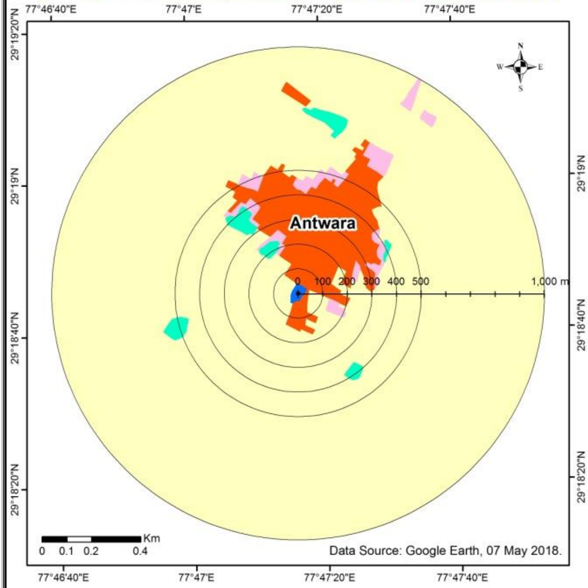
[redacted]

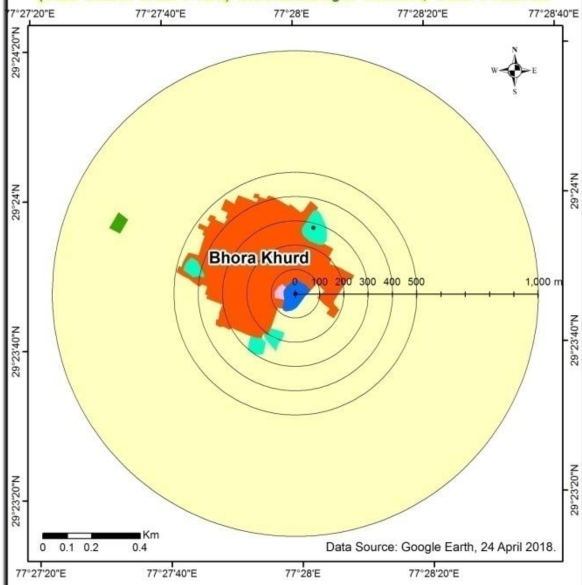
ANNEXURE-II: Land Use/Land Cover Map of Villages

Land Use/ Land Cover Map of Antwara Village
(1km Buffer from Pond) Muzaffarnagar District, Uttar Pradesh



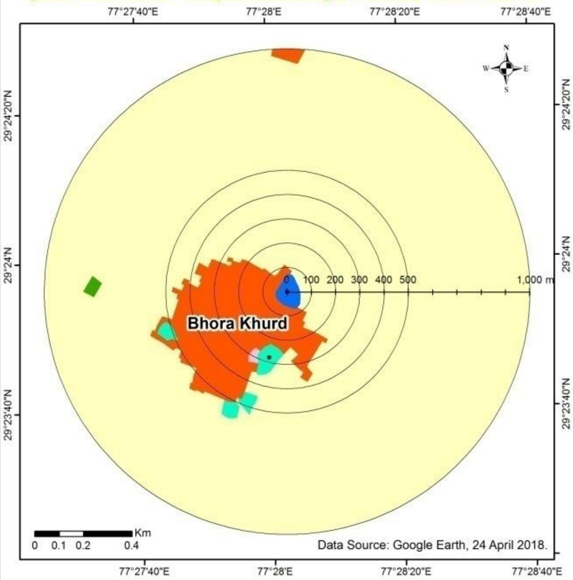
S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land	4.78	2.88	1.58	0.85	0.36	0.00
2	Crop Land	284.31	54.15	32.43	17.86	7.14	1.44
3	Settlement	21.56	19.30	14.60	8.86	4.68	1.40
4	Water Body (Other Ponds)	3.16	1.88	1.33	0.39	0.08	0.00
5	Water Body (Pond under Study)	0.31	0.31	0.31	0.31	0.31	0.31

Land Use/ Land Cover Map of Bhora Khurd (Pond 1) Village
(1km Buffer from Pond) Muzaffarnagar District, Uttar Pradesh



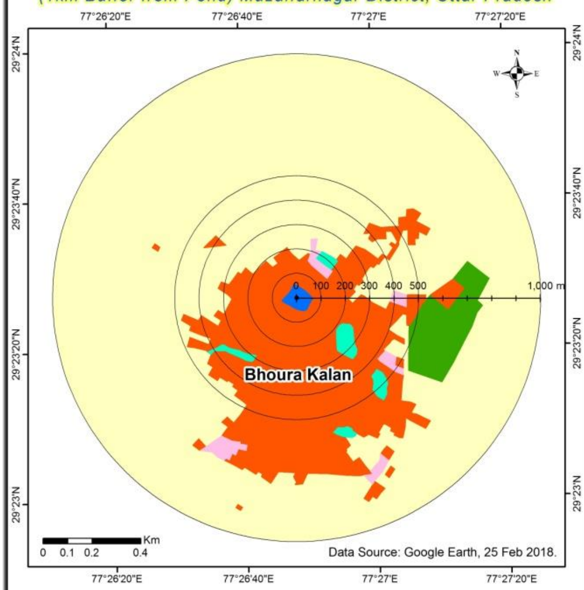
S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land	0.18	0.18	0.18	0.18	0.18	0.18
2	Crop Land	288.16	52.89	27.18	11.51	3.80	0.93
3	Orchard/ Grove	0.33	0.00	0.00	0.00	0.00	0.00
4	Settlement	22.38	22.38	20.20	14.2	7.50	1.13
5	Water Body (Other Ponds)	2.17	2.17	1.79	1.47	0.18	0.00
6	Water Body (Pond under Study)	0.89	0.89	0.89	0.89	0.89	0.89

Land Use/ Land Cover Map of Bhora Khurd (Pond 2) Village
(1km Buffer from Pond) Muzaffarnagar District, Uttar Pradesh

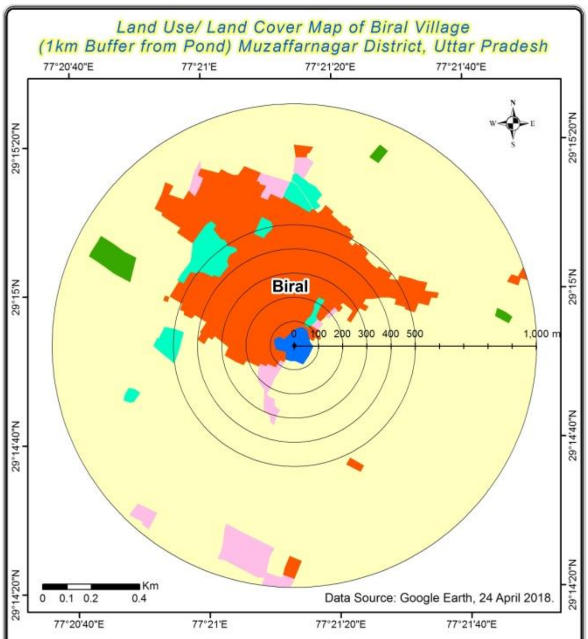


S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land	0.18	0.18	0.18	0.09	0.00	0.00
2	Crop Land	287.60	54.86	31.85	15.49	6.00	0.83
3	Orchard/ Grove	0.33	0.00	0.00	0.00	0.00	0.00
4	Settlement	22.94	21.24	16.34	11.15	5.58	1.33
5	Water Body (Other Ponds)	2.09	1.26	0.89	0.56	0.00	0.00
6	Water Body (Pond under Study)	0.98	0.98	0.98	0.98	0.98	0.98

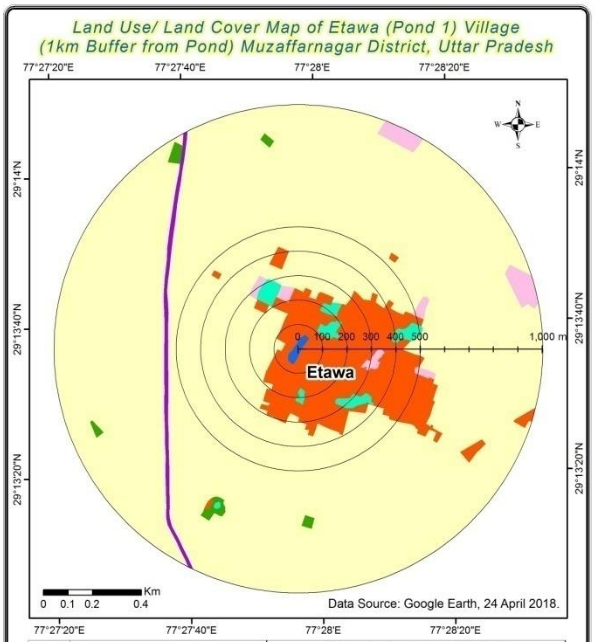
Land Use/ Land Cover Map of Bhoura Kalan Village
(1km Buffer from Pond) Muzaffarnagar District, Uttar Pradesh



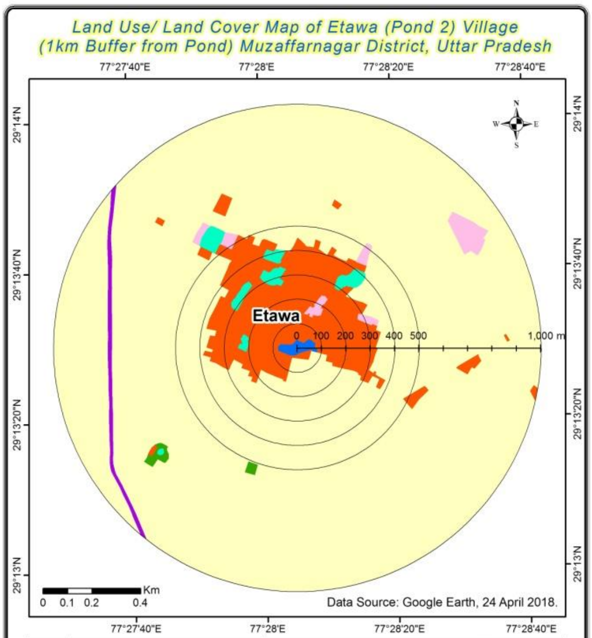
S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land	2.71	1.22	0.62	0.57	0.43	0.00
2	Crop Land	240.45	33.98	16.99	5.77	0.40	0.00
3	Orchard/ Grove	8.24	0.19	0.00	0.00	0.00	0.00
4	Settlement	59.39	40.32	30.18	20.03	10.75	2.34
5	Water Body (Other Ponds)	2.53	2.01	1.66	1.09	0.19	0.00
6	Water Body (Pond under Study)	0.80	0.80	0.80	0.80	0.80	0.80



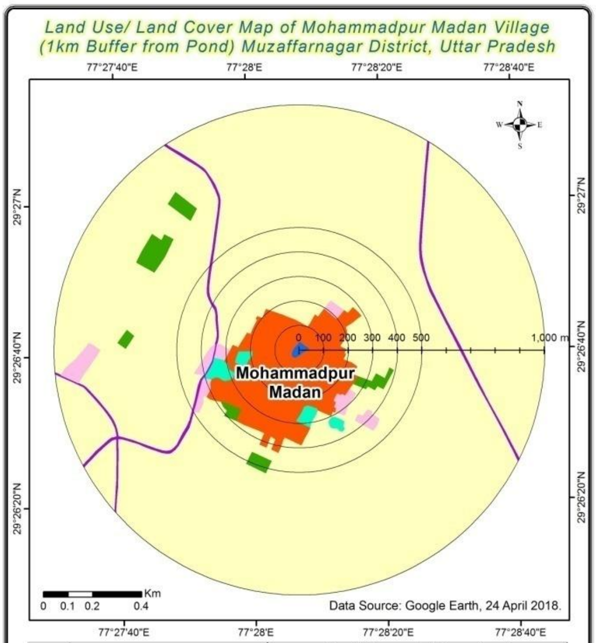
S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land / Brick Factory	6.94	1.31	1.31	1.23	0.73	0.03
2	Crop Land	252.18	43.83	26.39	13.27	4.87	0.61
3	Orchard/ Grove	2.27	0.00	0.00	0.00	0.00	0.00
4	Settlement	44.84	29.99	20.64	11.86	5.14	0.96
5	Water Body (Other Ponds)	6.37	1.86	0.37	0.37	0.30	0.02
6	Water Body (Pond under Study)	1.53	1.53	1.53	1.53	1.53	1.53



S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land / Brick Factory	3.88	0.95	0.90	0.48	0.00	0.00
2	Crop Land	274.53	48.75	24.73	9.20	2.79	0.18
3	Orchard/ Grove	1.21	0.00	0.00	0.00	0.00	0.00
4	Settlement	28.69	25.55	21.88	16.34	8.72	2.59
5	Water Body (Canal)	2.43	0.00	0.00	0.00	0.00	0.00
6	Water Body (Other Ponds)	3.02	2.91	2.37	1.88	0.68	0.00
7	Water Body (Pond under Study)	0.36	0.36	0.36	0.36	0.36	0.36

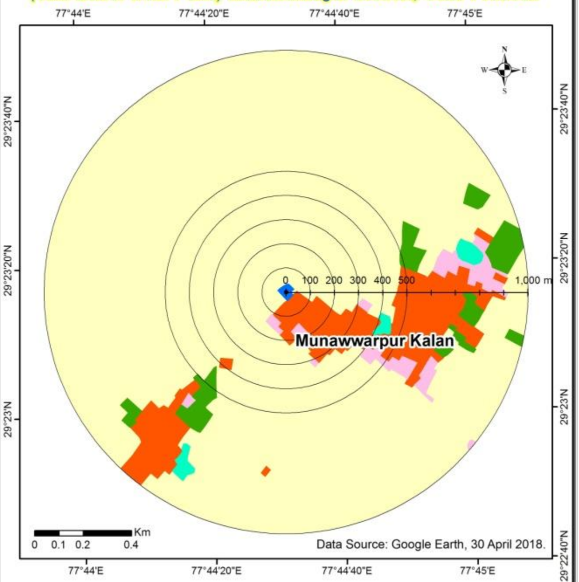


S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land / Brick Factory	3.00	0.83	0.57	0.41	0.24	0.00
2	Crop Land	276.34	47.98	22.66	9.49	3.50	0.65
3	Orchard/ Grove	0.59	0.00	0.00	0.00	0.00	0.00
4	Settlement	28.87	27.09	24.54	17.38	8.22	1.88
5	Water Body (Canal)	1.94	0.00	0.00	0.00	0.00	0.00
6	Water Body (Other Ponds)	2.78	2.01	1.87	0.38	0.00	0.00
7	Water Body (Pond under Study)	0.60	0.60	0.60	0.60	0.60	0.60



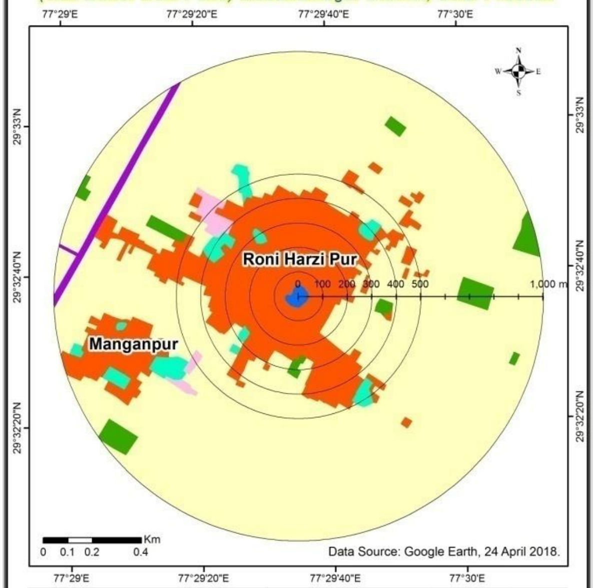
S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land / Brick Factory	3.49	2.40	1.69	0.82	0.04	0.00
2	Crop Land	281.76	51.97	25.22	9.44	1.43	0.00
3	Orchard/ Grove	3.51	1.26	0.91	0.14	0.00	0.00
4	Settlement	20.43	20.43	20.24	16.83	10.85	2.92
5	Water Body (Canal)	2.96	0.50	0.22	0.00	0.00	0.00
6	Water Body (Other Ponds)	1.74	1.74	1.74	0.82	0.02	0.00
7	Water Body (Pond under Study)	0.21	0.21	0.21	0.21	0.21	0.21

Land Use/ Land Cover Map of Munawwarpur Kalan Village (1km Buffer from Pond) Muzaffarnagar District, Uttar Pradesh



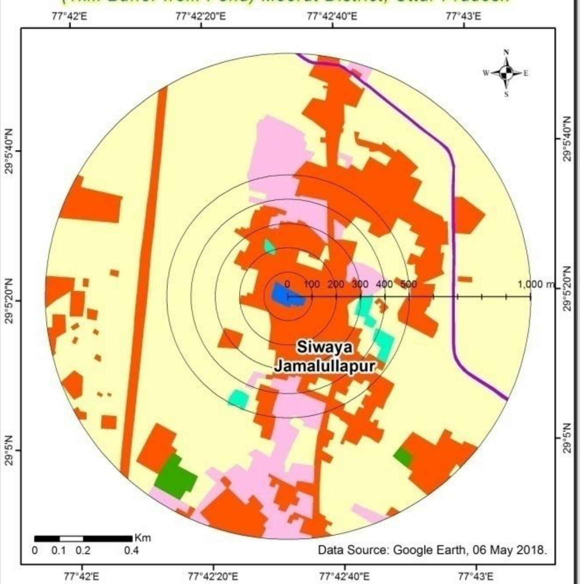
S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land	5.63	1.32	0.78	0.55	0.51	0.00
2	Crop Land	272.18	67.26	42.19	22.46	9.03	2.08
3	Orchard/ Grove	8.62	0.34	0.00	0.00	0.00	0.00
4	Settlement	25.45	8.89	7.00	4.98	2.74	0.79
5	Water Body (Other Ponds)	1.96	0.43	0.01	0.00	0.00	0.00
6	Water Body (Pond under Study)	0.27	0.27	0.27	0.27	0.27	0.27

Land Use/ Land Cover Map of Roni Harzi Pur Village (1km Buffer from Pond) Muzaffarnagar District, Uttar Pradesh



S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land	2.20	1.02	0.04	0.00	0.00	0.00
2	Crop Land	244.28	33.08	12.92	4.45	0.75	0.00
3	Orchard/ Grove	5.80	0.68	0.68	0.21	0.00	0.00
4	Settlement	53.31	40.51	34.57	22.64	11.20	2.53
5	Water Body (Canal)	2.65	0.00	0.00	0.00	0.00	0.00
6	Water Body (Other Ponds)	5.27	2.63	1.44	0.36	0.00	0.00
7	Water Body (Pond under Study)	0.60	0.60	0.60	0.60	0.60	0.60

Land Use/ Land Cover Map of Siwaya Jamalullapur Village (1km Buffer from Pond) Meerut District, Uttar Pradesh

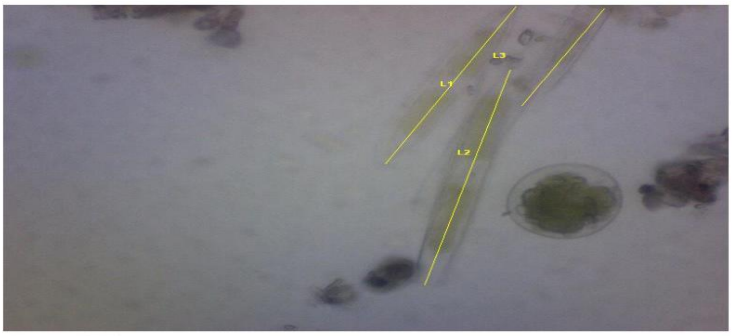


S.No.	LU/LC Class	Area (Ha) covered within a radius of					
		1000m	500m	400m	300m	200m	100m
1	Barren Land	24.56	8.59	4.80	0.47	0.00	0.00
2	Crop Land	200.72	35.40	18.77	7.56	2.22	0.00
3	Orchard/ Grove	2.18	0.00	0.00	0.00	0.00	0.00
4	Settlement / Major Road/ Railway	82.05	31.86	25.04	19.18	9.51	2.34
5	Water Body (Canal)	1.92	0.00	0.00	0.00	0.00	0.00
6	Water Body (Other Ponds)	1.89	1.87	0.83	0.25	0.03	0.00
7	Water Body (Pond under Study)	0.80	0.80	0.80	0.80	0.80	0.80

ANNEXURE-III: Identified Phyto and Zooplankton in Ponds

Phytoplankton

Report Name : Syndea Date : 06-28-2017

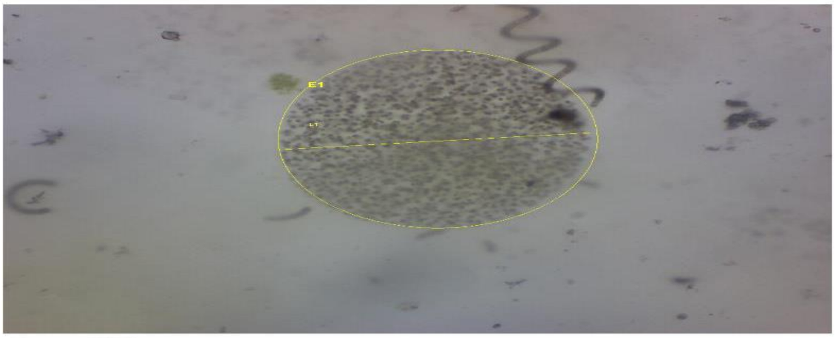


Measurement Details

L1	Width : 143	Length : 288
L2	Width : 94	Length : 394
L3	Width : 91	Length : 178

Micricystis sps

Report Name : RMOD NIH Roorkee Date : 06-29-2017

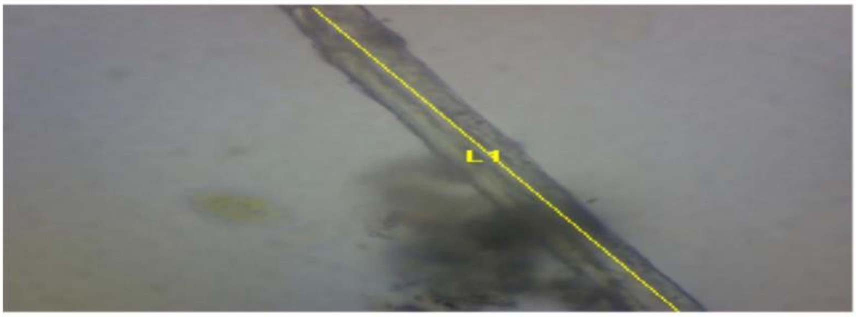


Measurement Details

L1	Width : 478	Length : 49		
E1	Area : 200163.4343	Perimeter : 2518.8358	Major Axis : 259	Minor Axis : 246

RMOD NIH Roorkee

Report Name : Pannularia Date : 06-28-2017

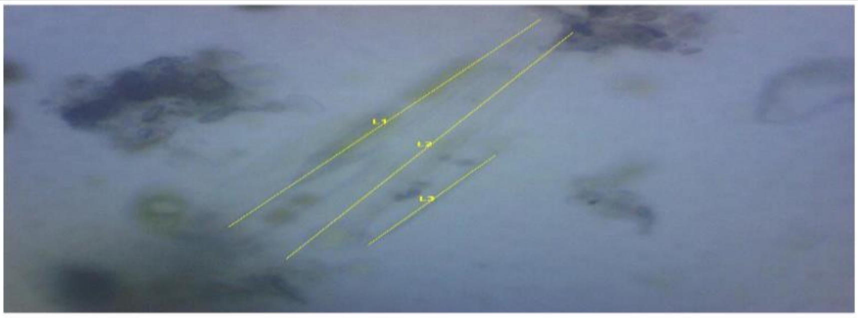


Measurement Details

L1	Width : 137	Length : 236

RMOD NIH Roorkee

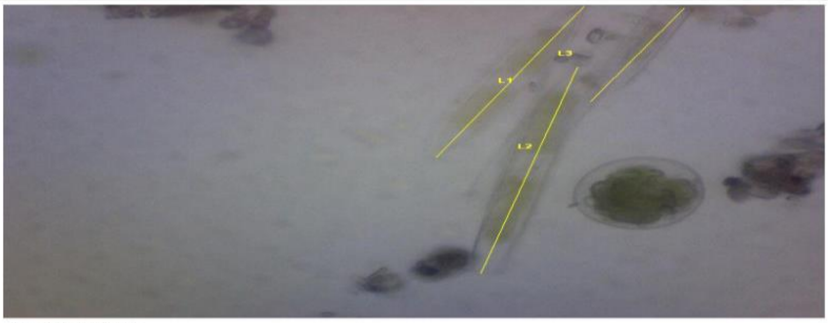
Report Name : Nitizschia   Date : 06-28-2017



Measurement Details

L1	Width : 292	Length : 403
L2	Width : 269	Length : 440
L3	Width : 119	Length : 174

Report Name : Navicula   Date : 06-28-2017

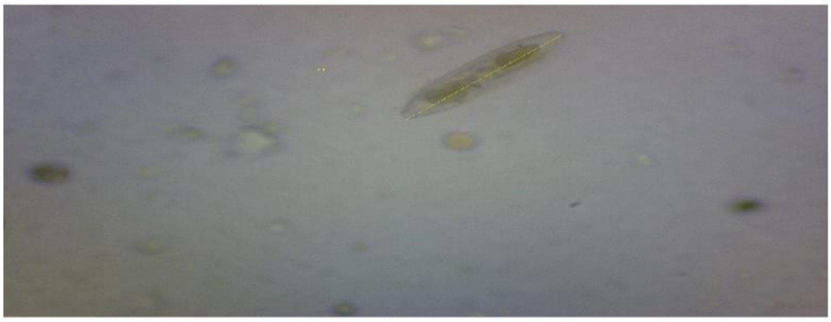


Measurement Details

L1	Width : 143	Length : 288
L2	Width : 94	Length : 394
L3	Width : 91	Length : 178

RMOD NIH Roorkee

Report Name : Navicula species   Date : 06-28-2017

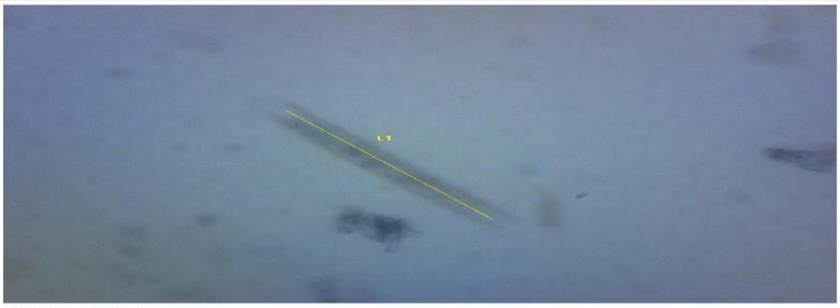


Measurement Details

L1	Width : 301	Length : 324

RMOD NIH Roorkee

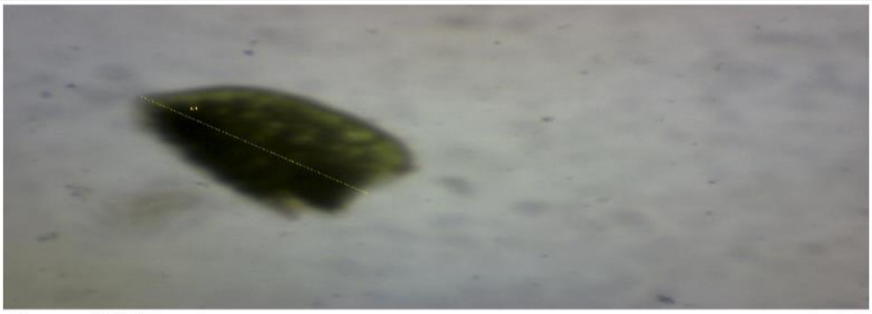
Report Name : Microspora Date : 06-28-2017



Measurement Details

L1 Width : 197 Length : 217

Report Name : Gonium Date : 06-28-2017

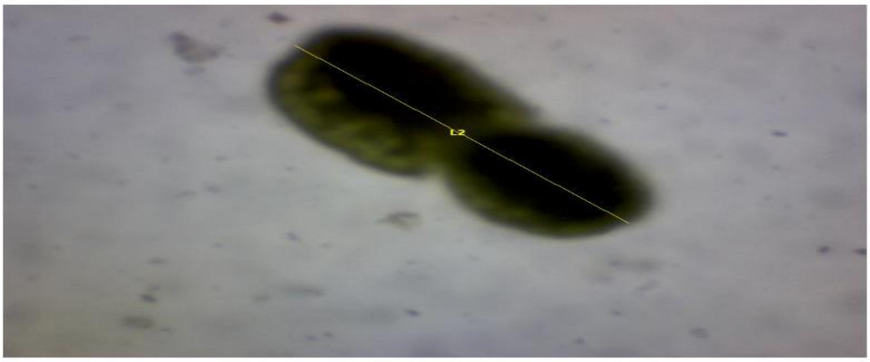


Measurement Details

L1 Width : 421 Length : 384

Phytoplankton

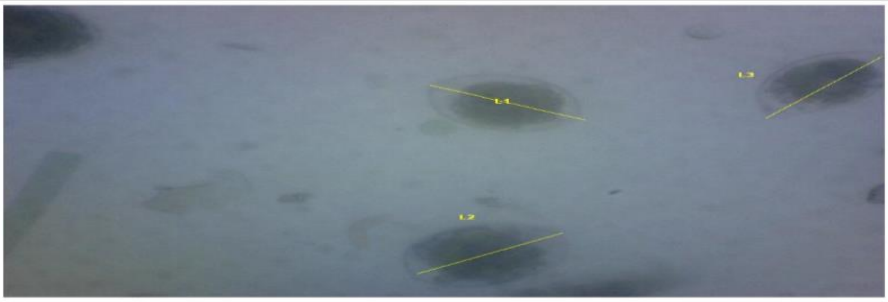
Report Name : Euglina species Date : 06-28-2017



Measurement Details

L2 Width : 0.308 Length : 0.301

Report Name : Eudorina, Pandorina Date : 06-28-2017

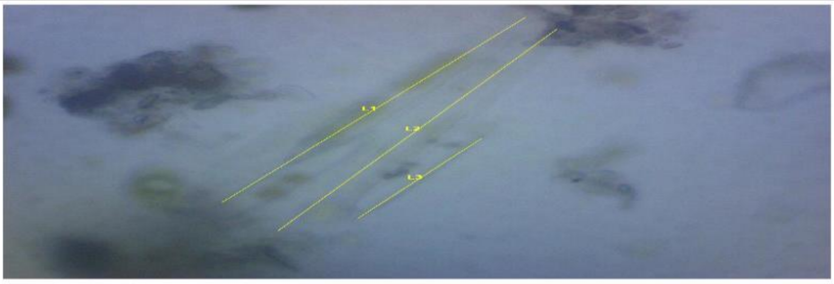


Measurement Details

L1	Width : 141	Length : 72
L2	Width : 131	Length : 83
L3	Width : 105	Length : 126

RMOD NIH Roorkee

Report Name : Closterium Date : 06-28-2017

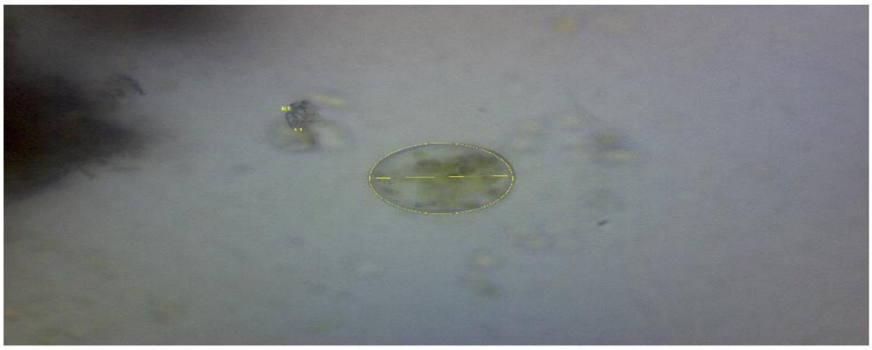


Measurement Details

L1	Width : 292	Length : 403
L2	Width : 269	Length : 440
L3	Width : 119	Length : 174

RMOD NIH Roorkee

Report Name : Chlorella Date : 06-28-2017

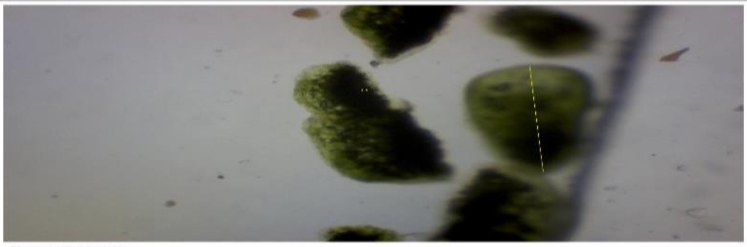


Measurement Details

L1 Width : 270 Length : 10

E1 Area : 127064.8565 Perimeter : 2011.6814 Major Axis : 214 Minor Axis : 189

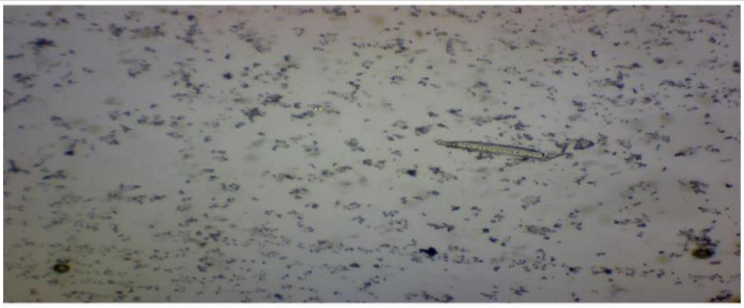
Report Name : Chiadomonus Date : 06-28-2017



Measurement Details

L1 Width : 29 Length : 536

Report Name : Syndra Date : 06-28-2017

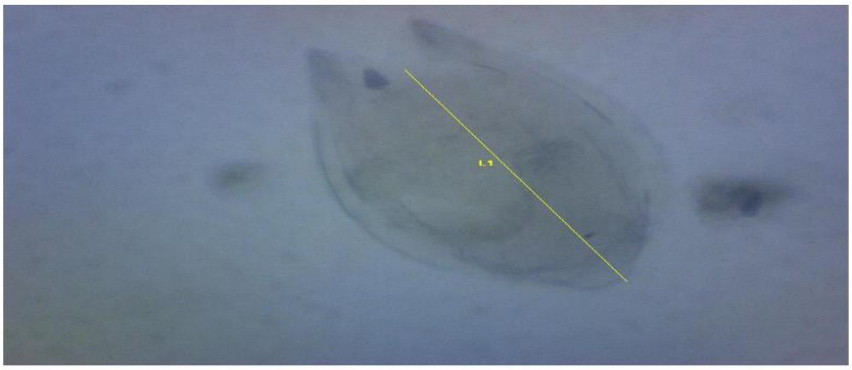


Measurement Details

L1 Width : 242 Length : 59

Zooplankton :

Report Name : Brachionus bidentata Date : 06-28-2017

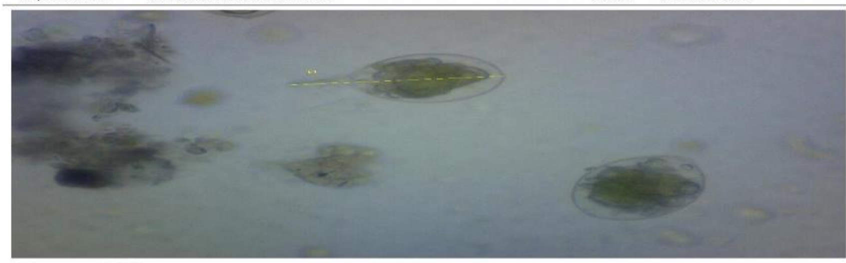


Measurement Details

L1 Width : 210 Length : 352

RMOD NIH Roorkee

Report Name : Monostyla clostocera Date : 06-28-2017



Measurement Details

L1 Width : 330 Length : 37

ANNEXURE-IV: Photographs of Field Visits at Pond Sites

(Water Quality, GWL, Collection of Sludge/Soil Samples, Infiltration Tests, Visit of Director-R&D, MoWR)

1. MUNNAWARPUR KALA


Location of pond ingoogle map ***Pond status (beforerejuvenation)*** ***Pond status (afterdesludging)***


DuringConstruction ***(Visit ofDirector, R&D, Dtd. 2.4.19)***



After Rejuvenation (Floating Wetland)

Infiltration test at pond bed

Soil Sample collection

Ground Water Level measurement and Sample Collection

2. ANTWARA

Location of pond ingoogle map

Pond status before rejuvenation

(pond satsus after de-sluging)

During Construction

After Rejuvenation

Ground Water Level measurement and WQ Sample Collection

Infiltration Tests at pond bottom

3. SIWAYA

Location of pond ingooglemap ***Pond statusbefore rejuvenation*** ***Pond status afterdesludging***

Soil Sample Collection from Pond bed

Ground Water Level measurement& water sample collection

After Rejuvenation

Visit of NIH & NPCC Team

4. <u>PAVLI KHAS</u>

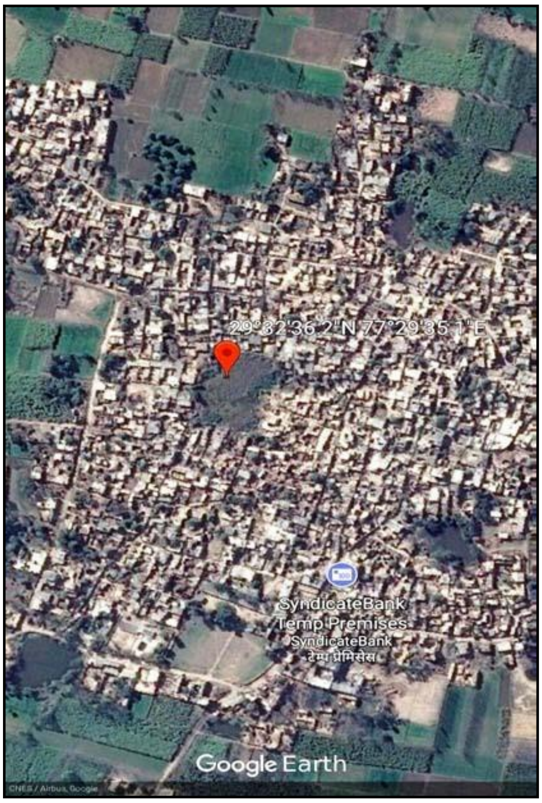
Ground Water Level measurement & Sample Collection

Pond before rejuvenation

Pond during rejuvenationwork

After Rejuvenation

5. RONI HAZIPUR



Ground Water Level measurement & Sample collection

Pond status before Rejuvenation

Duringrejuvenationwork

After Rejuvenation

Soil samplecollection

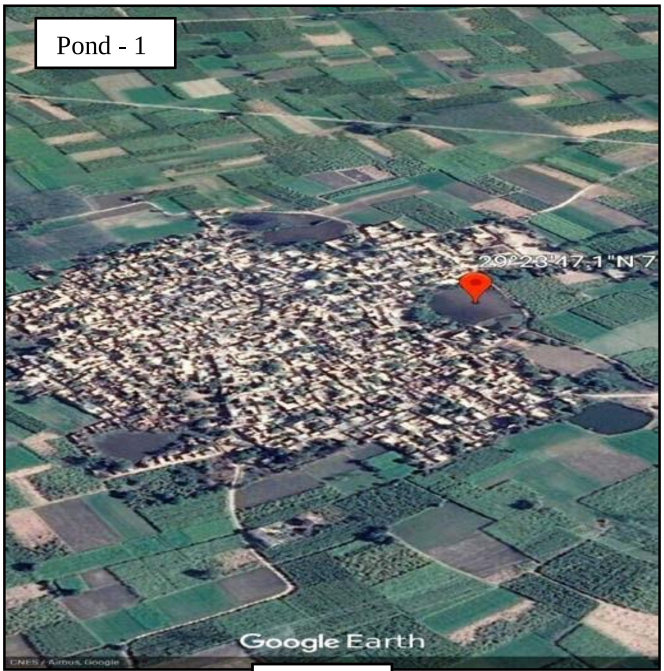
6. MOHAMMADPUR MADAN

Ground Water Level measurement & Sample Collection

Pond before Rejuvenation

After Rejuvenation

7. <u>BHORA KHURD (1 &2)</u>



Pond - 1

Pond - 2

Pond (Before Rejuvenation)

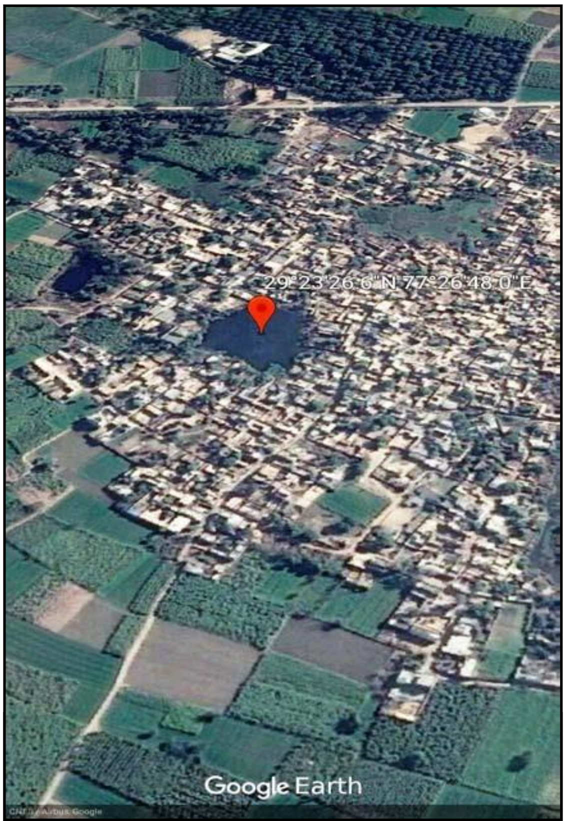
Infiltration Test

During Construction Pond-1After rejuvenation Pond-1

After Rejuvenation Pond-1

After Rejuvenation Pond-2

8. BHORA KALA



Infiltration test

9. BIRAL

Before Rejuvenation

During Construction

After Construction

Soil Sample Collection

Groundwater Sample Collection

10. <u>ITAVA (1&2)</u>

Location of pond ingooglemap

Pond status before rejuvenation

Pond status after desludging

Ground Water Level measurement andSampleCollection

Soil SampleCollection

Infiltration Test

After Rejuvenation

Pond 2

Pond status before rejuvenation

Pond status after desludging

ANNEXURE-V: Field Visit Report of Director R&D, DoWR, RD & GR

Director (R&D) Site Visit Report for Review of Prpgect-I Entitled "Action Research on **IWRM Plan for Water** Security in Identified Villages of Western U.P."

I. **Review** meeting was held at NIH, **Rookreeon 1/4/2019. The following** team members were present:

1. Shri.AnujKanwal,DirectorR&D(MoWR,RD&GR)
2. Dr. V.C. Goyal, Scientist G &HeadRMOD
3 Er. OmkarSingh, Scientist F,RMOD
4 Er. DigambarSingh, Scientist C, RMOD
5. Dr. AmranderBhushan, Research Scientist
6 Sh. NageshwarRao Allaka, R.A,RMOD
7. Dr. N. G. Shrivastava,(SRP)
8. Dr. NihalSingh, ResearchScientist
9. Dr. KalzangMathus, ResearchAssociate
10. Sh. Sandeep Yadav, ResearchAssociate
11. Sh. SubhashVyas, FieldAssistant

II. **The site visit** was organized for **Shri. AnujKanwal, Director,** R&D, MoWR, GR&RD, Govt. of **India,** New Delhi from **02.04.2019 to03.04.2019.**

IH. The following team members were present during site visit:

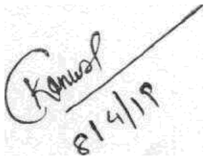
NIH Roorkee	NPCC	Contractors of NPCC
1 Dr.NGShrivastava(SRP)	1. Shri. H.P.Singh(PM)	1.Shri. NaveenTyagi
2 Dr. KalzangJRP(RA)	2. Shri.Anuj(JE)	2. Shri. VivekSandeep Yadav JRP
3 3. ShriGovind(JE)	3. Shri. AdeshTyagi	
4. Shri SubhashVyas(PA)	4. Shri Vijnay(JE)	4 Shri. SamathBalayan
	5. Shri. Ankush(JR)	5 Shri. PratapSingh
	6. Shri. VabhavPratapSing (JE)	

IV. The Following Sites werevisited:

01.04.2019	02.04.2019	03.04.2019
01. IbrahimpurMasahi(InternalStudyofMH)	1. MunnawarpurKalan	1 l. SiwayaJamallulapur
	2. Antwara	12. PavliKhas
	3. ItawaPond1	
	4. ItawaPond2	
	5. Biral	
	6. MohmadpurPond2	
	7. BhoraKaian	
	8. BhoraKurd Pondl	
	9. BhoraKhurdPond2	
	10. RoniHazipur	

V. The Following Observation/ Suggestions were made atsite:

1. Dewatering and Desludging of all the ponds completed andsatisfactory.
2. Construction Work at MunnawarpurKalan (Periphery drain Completed &Common Pit,Screening Chamber, Grit Chamber and Sedimentation Chamber work is in progress and assuredbyNPCC will be completed by the end of this month i.e. 30.04.2019.
3. The whole cost estimate for this action research project need to be revised basedon:
    a. Thewetlandtechnologyforthewholepondneedtobeworkedoutwithoutanymajor Civilwork
    b. Civilworksneedtobedroppedforallthepondswhereitisyettostart.
    c. The periphery drain may be replaced with underground PVC heavy grade pipes withsuitablemanholes.
    d. Domestic Solid Waste is still being disposed offin the cleared pond by the community. Hence, protective sheets around the embankments of ponds need to be provided at the required places along with slogans to save »'aterwritten onthem.
    e. Compaction of sides embankment with suitable binding material so that soil erosioncanbe control and stabilized.
    f. For the Capacity building programmehelp of suitable local NGO may beinvolved.



ANNEXURE-VI: VISIT REPORT OF NIH TEAM

VISIT REPORT OF NIH TEAM
(Duration of Visit: 27-29 November, 2019)
PROJECT: ACTION RESEARCH ON IWRM PLAN FOR WATER SECURITY IN IDENTIFIED VILLAGES OF WESTERN U.P.

(Sponsored by DoWR, RD&GR, Ministry of Jal Shakti, GOI)-Through INCSW

VISITING TEAM MEMBERS

TEAM MEMBERS (NIH)	TEAM MEMBERS (NPCC Noida/Meerut)
Dr. V.C. Goyal, Sc. G. (PI) **Er.Omkar Singh, Sc. F (CO-PI)** **Dr. Rajesh Singh, Sc. D** **Er. Digambar Singh, Sc. C** **Mr. Rajneesh Goyal, AO-Finance** **Mr. Mahendra Singh, PS to FO**	**Er. H.P. Singh, Project manager** **Er. Vaibhav Rajput, Site Engineer** **Er. Vinay Sharma, Site Engineer** **Er. Anuj Kumar, Site Engineer**
Dr. N.G. Shrivastava, RPS **Er. Subhash Vyas, Field Assistant**	

PROGRAM OF TEAM VISIT

27.11.2019	Munnwarpur Kalan, Antwara, Siwaya, Pavli Khas
28.11.2019	Roni Hazipur, Bhora Kalan, BhoraKhurd -1, BhoraKhurd- 2, Itava -1, Itava -2, Mohmmadpur Madan
29.11.2019	Biral and NPCC Office Meerut

General suggestions common for all 12 pond sites:

Minor suggestions to improve appearance of the pond sites e.g. sign board, inlet were given by the committee to NPCC for immediate compliance during above visits at all pond sites.

1. VILLAGE POND: MUNNAWARPUR KALAN



Before Rejuvenation work | During Rejuvenation Work

Floating Wetland-After Rejuvenation

Present Status (Nov. 2019)

Present Status (Nov. 2019)

Present Status (Nov. 2019)

- Visiting committee observed that pond Rejuvenation work has been completed satisfactory. The construction work of Inlet Chamber, Grit Chamber, Sedimentation Tank, Periphery Drain and Floating Wetland installation is completed.
- Dewatering and Desludging **(6,274 m^3)** was carried out.
- Storage capacity of pond before and after rejuvenation was **3,830 m^3** and **10,104 m^3,** respectively.
- The floating wetland is designed for Treatment of **0.24 mld**wastewater load of this village

2. VILLAGE POND: ANTWARA

Before Rejuvenation work

During Rejuvenation Work

After Rejuvenation (Field Investigation)

Visit of Director R&D MoJS, April 2019

Present Status (Nov. 2019)

- No Unwanted weeds observed in this Pond.
- Dewatering and Desludging **(7,554 m^3)** was carried out from the pond.
- Storage capacity of pond before and after rejuvenation was **1,519 m^3** and **9,072 m^3**respectively.

3. VILLAGE POND: SIWAYA

Before Rejuvenation work **During Rejuvenation Work**

After Rejuvenation **Field Investigations**

Present Status (Nov. 2019)

- It is observed that Water Hyacinth growth reappeared near pond shore since the work was done in October/Nov 2018. It is required to be removed completely which is not being done by concerned Gram Panchayat.
- Dewatering and Desludging **(19,397 m^3)** was carried out from the pond.
- Storage capacity of pond before and after rejuvenation was **7,422 m^3** and **26,819 m^3**respectively.

4. VILLAGE POND: PAVLI KHAS

Before Rejuvenation work

During Rejuvenation Work

After Rejuvenation

After Rejuvenation

Present Status (Nov. 2019)

- Visiting committee observed that pond Rejuvenation work has been completed.
- No unwanted weeds observed in Pond.
- Dewatering and Desludging (22,976 **m^3)** was carried out.
- Storage capacity of pond before and after rejuvenation was **9,512 m^3** and **32,488 m^3**respectively.
- Inlet chamber with Screening bar is provided to control Solid Waste in to the pond.

5. VILLAGE POND: RONI HAZIPUR

Before Rejuvenation work **During Rejuvenation Work**

After Rejuvenation (During Visit of Director R&D, MoJS) April 2019

Present Status (Nov. 2019)

Present Status (Nov. 2019)

- It is observed that Water Hyacinth growth reappeared near pond shore since the work was done in October/Nov 2018. It is required to be removed completely which is not being done by concerned Gram Panchayat.
- Dewatering and Desludging (16,346 m^3) was carried out from the pond.
- Storage capacity of pond before and after rejuvenation was 941m^3 and 17,286m^3respectively.

6. VILLAGE POND: BHORA KALAN

Before Rejuvenation work

During Rejuvenation Work

During Rejuvenation

Present Status (Nov. 2019)

- It is observed that Water Hyacinth growth reappeared nearby Pond Shore.Since the work was done in October/Nov 2018. It is required to be removed completely which is not being done by concerned Gram Panchayat.
- Dewatering and Desludging (23,472 m^3) was carried out from the pond.
- Storage capacity of pond before and after rejuvenation was 11,286 m^3 and 34,759 m^3respectively.

7. VILLAGE POND: BHORA KHUD-1

Before Rejuvenation work **During Rejuvenation Work**

During Rejuvenation Work **After Rejuvenation**

Present Status (Nov. 2019)

- It is observed that Water Hyacinth growth reappeared since the work was done in October/Nov 2018. It is required to be removed completely which is not being done by concerned Gram Panchayat.
- Dewatering and Desludging (29,501 m^3) was carried out from the pond.
- Storage capacity of pond before and after rejuvenation was 16,364 m^3 and 45,865 m^3respectively.

8. VILLAGE POND: BHORA KHURD-2

Before Rejuvenation work

During Rejuvenation Work

After Rejuvenation

Present Status (Nov. 2019)

- It is observed that Water Hyacinth growth reappeared since the work was done in October/Nov 2018. It is required to be removed completely which is not being done by concerned Gram Panchayat.
- Dewatering and Desludging (23,586 m^3) was carried out from the pond.
- Storage capacity of pond before and after rejuvenation was 11,822 m^3 and 35,408 m^3respectively.

9. VILLAGE POND: ITAWA-1

Before Rejuvenation work

During Rejuvenation Work

After Rejuvenation

Present status (Nov. 2019)

- It is observed that Water Hyacinth growth reappeared since the work was done in October/Nov 2018. It is required to be removed completely which is not being done by concerned Gram Panchayat.
- Dewatering and Desludging (18,903 m^3) was carried out from the pond.
- Storage capacity of pond before and after rejuvenation was 5,365 m^3 and 24,268 m^3respectively.

10. VILLAGE POND: ITAWA-2

Before Rejuvenation work

During Rejuvenation Work

After Rejuvenation (Field Investigations)

Present Status (Nov. 2019)

- It is observed that Water Hyacinth growth reappeared since the work was done in October/Nov 2018. It is required to be removed completely which is not being done by concerned Gram Panchayat.
- Dewatering and Desludging (18,304 m^3) was carried out from the pond.
- Storage capacity of pond before and after rejuvenation was 2218 m^3 and 20,522 m^3respectively.

11. VILLAGE POND: MOHAMDPUR MADAN

Before Rejuvenation work

During Rejuvenation Work

After Rejuvenation

Present Status (Nov. 2019)

- It is observed that Water Hyacinth growth reappeared since the work was done in October/Nov 2018. It is required to be removed completely which is not being done by concerned Gram Panchayat.
- Dewatering and Desludging **(10,207m^3)** was carried out from the pond.
- Storage capacity of pond before and after rejuvenation was **3,274 m^3** and **13,481 m^3**respectively.

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12. VILLAGE POND: BIRAL

Before Rejuvenation work

During Rejuvenation

During Rejuvenation (Field Investigation)

Present Status (Nov. 2019)

- No unwanted weeds (water hyacinth) observed except emergence of algae near shorein this Pond.
- Dewatering and Desludging (19,815 m^3) was carried out from the pond.
- Storage capacity of pond before and after rejuvenation was 13,703 m^3 and 33,518 m^3respectively

General Observationsof the Villagers on Rejuvenation of Village Ponds

The observation made by the villagers are:

1. Before Rejuvenation, the ponds were almost dead and full of vegetation growth and sludge. Due to the same, bad odour/smell was emanating from the ponds. In monsoon season, due to reduced capacity of ponds, the streets and nearby homes were getting flooded.

2. Most of the villagers are happy and satisfied with the work and they informed that they did not face the problem of flooding during the last monsoon. However, their concern was related to the beautification of the embankments.

Observation of the Committee members

The general observation of Visiting NIH committee is followed–

1. Depth and storage capacity of all the ponds has substantially increased. In almost all the ponds, NPCC has removed sludge more than the estimated amount, as per the request of local Gram Panchayats.

2. The ecosystem of most of the pond was observed improved except few where water hyacinth has reappeared after the rejuvenation work.

Committee Suggestion to Gram Panchayats

The Following suggestions were given by Visiting NIH committee and NPCC Ltd to the Gram Panchayats –

1. The ponds and its surrounding should be kept clean and disposal of solid waste in and around the ponds should be avoided.
2. The inlet drains / chamber to the ponds should be regularly cleaned, as and when required.

3. The water hyacinth grows in the water bodies with high nutrient load, and all the ponds under this project are receiving the domestic wastewater emanating from the village, due to which the appearance of these aquatic plants is normally expected. However, these should be removed immediately, if observed.

4. The GP should try to eliminate any encroachment by any villagers in future.

5. Mass awareness activities should be carried out by the concerned GP's to properly maintain and utilize pond's water for benefit of society.