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Jhalesh Kumar
Department of Soil and Water Engineering, SV College of Agricultural Engineering and Research Station, FAE, Raipur, Chhattisgarh, India

VK Pandey
Department of Soil and Water Engineering, SV College of Agricultural Engineering and Research Station, FAE, Raipur, Chhattisgarh, India

Rajesh Singh
Environmental Hydrology Division, National Institute of Hydrology, Roorkee, Uttarakhand, India

VC Goyal
Research Management and Outreach Division, National Institute of Hydrology, Roorkee, Uttarakhand, India

Omkar Singh
Research Management and Outreach Division, National Institute of Hydrology, Roorkee, Uttarakhand, India

Corresponding Author
Jhalesh Kumar
Department of Soil and Water Engineering, SV College of Agricultural Engineering and Research Station, FAE, Raipur, Chhattisgarh, India

Performance of constructed wetland installed in Ibrahimpur village, Haridwar district, Uttarakhand state

Jhalesh Kumar, VK Pandey, Rajesh Singh, VC Goyal and Omkar Singh

Abstract
With the current situation of water scarcity, proper management of water resource and reuse wastewater can be help to avoid water crisis. We require increasing awareness to the peoples that our sources of freshwater are limited and we need to protect them both quantity as well as quality of water. This water scarcity not only affects water community but also decision maker as well as every human being. That's why solve this water scarcity we have installed constructed wetland in Ibrahimpur for domestic wastewater treatment. The wastewater samples were collected in Village Ibrahimpur, Haridwar District Uttarakhand State during November 2018 to December 2020. I have collected wastewater sample at inlet of Grit Chamber, after passing through grit chamber, before and after passing to constructed wetland and stored pond water comes after treatment on different interval weekly and monthly and analyzed these samples on site and laboratory of institute. I have analyzed 10 water quality parameters which is showed that waste water quality. I have found average pollutants removal from domestic wastewater like water quality parameters pH value is 6.47%, Electrical Conductivity (µs/cm) is 45.89% and improve/increase Dissolved Oxygen (mg/l) is 824.44%, Biological Oxygen Demand (mg/l) is 83.17% and Chemical Oxygen Demand (mg/l) is 80.92%. Bacteriological parameters (MPN/100ml.) were also analyzed in institute laboratory and found average removal of E. Coliform is 99.94% and Total Coliform is 99.6%. Nitrate-Nitrogen, Ammonical-Nitrogen and Phosphate (mg/l) were removed 29.93, 81.01 and 74.96% respectively.

Keywords: constructed wetland, coliform, wastewater, chemical oxygen demand, reagent, biochemical oxygen demand and MPN

Introduction

Wastewater refers to any liquid waste or sewage that comes from households, hospitals, factories and any other structure that uses water in its facilities. It is the byproduct of the usage of water. So, whenever you use the faucets or flush a toilet the water that is used will eventually make it to the ocean and other large bodies of water. Essentially, any water that you use in a household or office will eventually contribute to the volume of wastewater that the property produces. The use of water will fall under either internal or external use. Internal use includes the use of water in faucets, toilets and shower. This refers to any water that is coursed through a household's internal drainage. About 60% of wastewater is made up of water that is used internally. External use includes water that is used to clean garages, irrigate crops and water gardens. These do not usually make it to sewage system as they are absorbed by the soil or they simply evaporate. However, that doesn't mean that there are not instances when externally used water find its way to drainage systems. This is what makes up 40% of the total wastewater.

Unfortunately, the effects of sewage on the environment are largely negative. It needs to be properly treated before it can be disposed of – usually into the ocean. There are two problems, however. If sewage is only partially treated before it is disposed of, it can contaminate water and harm huge amounts of wildlife.

Alternatively, leaking or flooding can cause completely untreated sewage to enter rivers and other water sources, causing them to become polluted. The consequences aren't great. In September, a large part of the River Trent was polluted by sewage in Staffordshire. Over 15,000 fish were killed, and it would have been worse if the sewage had reached a human water source. Contamination of water sources can cause diseases to spread, such as e-coli, diarrhea and hepatitis A. It isn't all bad though. As well as pollutants, human sewage contains a pool of information that can be used to monitor a range of areas.

While most research has focused on monitoring the use of illegal drugs, it is now being extended to the other potential fields of research. Determining the presence of pesticide metabolites, for instance, can be beneficial for the food and agricultural sector. Analyzing wastewater can also detect markers of oxidative stress in collective samples. This is essentially an indication that bodies are unable to neutralize certain diseases. It can help researchers determine the effects of environmental pollution on particular communities.

Materials and Methods

Experimental Site: Ibrahimpur Masahi is a large village located in Roorkee Tehsil of Haridwar District, Uttarakhand State with total 1148 families residing. The Ibrahimpur Masahi village has population of 6664 of which 3534 are males while 3130 are females as per Population Census 2011. This village placed on top place and domestic wastewater goes out in different direction according to slope. In constructed wetland only 100 houses wastewater comes and their discharge per day was 0.04 million liter per day (MLD).

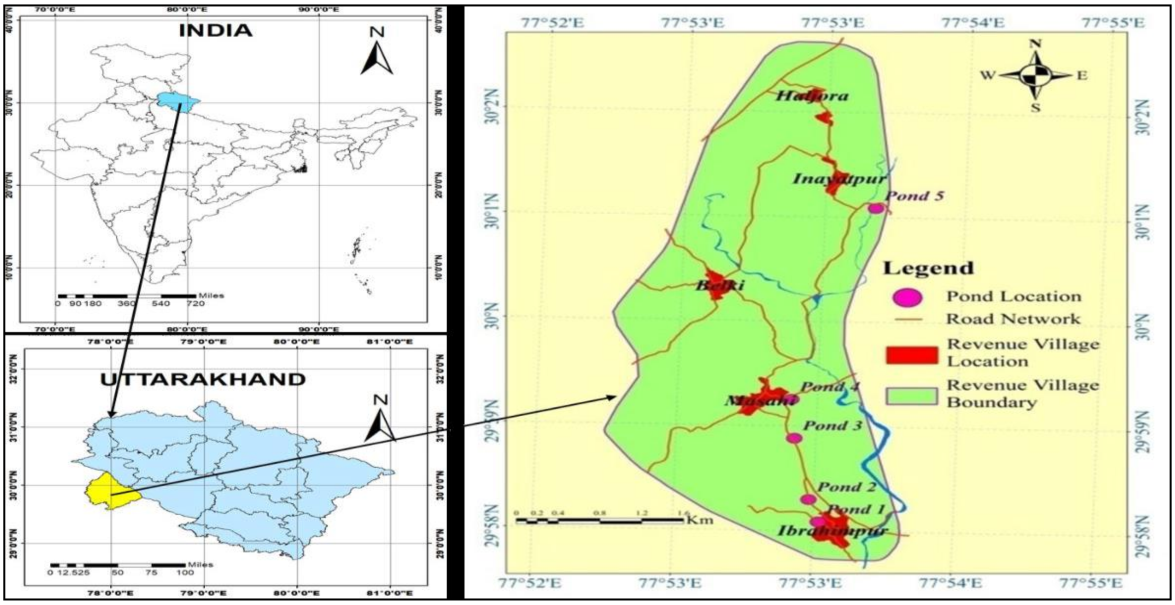

Fig 1: Geographical Location of Experimental Site

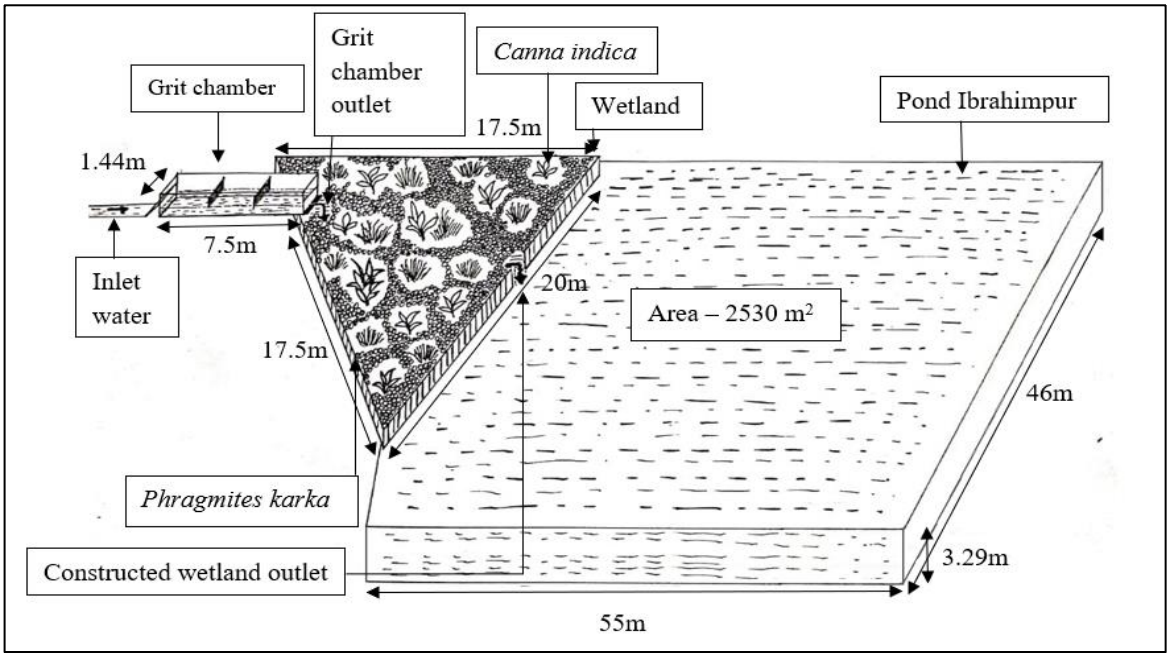

Fig 2: Layout of Construvted wetland at Ibtahimpur Village

Sampling procedure

1. Upon arrival at the sampling site, check the GPS coordinates to locate the predetermined site. If no coordinates are given, take GPS coordinates along the shoreline at the first sampling point and record them.
2. Label the sample bottles with the sampling location, replicate number, date and time of collection.
3. Before collecting samples, prepare a field blank by pouring 100 ml distilled/deionized water into a 120 ml sample bottle. Place the field blank in the cooler. Perform one field blank daily at the first sampling location and handle and process as a regular sample.
4. Gather the field thermometer and 3 unopened sample bottles and wade into the reservoir until knee deep.
5. Measure and record the water temperature.
6. Remove the lid of the sample bottle and invert the bottle

to a depth of approximately 12-18 inches to collect the water sample while avoiding surface scum and bottom sediments. To avoid contamination, be careful not to touch the inside of the lid or bottle.

7. Replace the lid securely and shake the bottle for a few seconds to mix the sample and sodium thiosulfate. Walk 10 feet in one direction (paralleling the shoreline) to grab the second replicate; then walk another 10 feet further to grab the third replicate sample. Take extra care when paralleling the shoreline to minimize disturbance of the bottom sediments (i.e. do not sample the kicked up sediment plume).
8. Store the samples in a cooler on wet ice or ice packs.
9. Fill out field sheet accurately and completely.

Samples Collection: Wastewater comes from houses and they enter on grit chamber. We have collected first samples for water quality analysis before entering this wastewater in grit chamber. This domestic wastewater passes through grit chamber and entering to the constructed wetland. After passing through grit chamber and before entering constructed wetland we have collected second samples. After passing through constructed wetland this wastewater has treated and entered on storage pond. We have collected third sample after passing through constructed wetland and before entering pond to evaluate performance of wetland. Treated wastewater directly discharged in storage pond water. We have collected forth sample on middle of pond water which is used for irrigation. But in monsoon season constructed wetland had on submerged condition so we not able to collected samples from constructed wetland outlet and grit chamber outlet.

Sample Bottles: We take 1liters unpreserved sample for analysis of BOD, pH, Electric conductivity, Nitrate-Nitrogen, Ammonical-Nitrogen, phosphate. We are take100 ml water sample for bacterial analysis (E. Coliform and Total Coliform). 60 ml water sample is takes on plastic bottle for COD analysis and this sample is preserved by 10 drop (1ml) H_2SO_4.300ml water sample is take on DO bottles and preserved by 1ml magnesium sulphate and 1 ml alkali azide and put cap and tight properly and sake well. Domestic wastewater sample was collected at every month and these were analyzed in institutional laboratory.

Table 1: Location of sampling site in Ibrahimpur Village

S. No.	Sample Name	Latitude	Longitude
1.	Grit Chamber Inlet	29°58'23.08"N	77°53'24.16"E
2.	Pond water sample Ibrahimpur	29°58'24.25"N	77°53'22.45"E

Samples Analysis: Water quality parameters pH, electrical conductivity and Dissolved Oxygen were measured on site with the help of WTW Multi 3220 portable instrument. Temperature and time were also displayed on screen and these readings were noted on note book. Sometimes Dissolved Oxygen was calculated by Winkler Method on institutional laboratory following APHA procedure or guideline. BOD was measured by OXITOP Bottle which displayed direct reading of BOD on screen on its cap. COD was analyzed through titration method in which 10ml sample, 6ml potassium dichromate and 14ml concentrated Hydrogen Sulphate were digested on digesting chamber and titrate with Ferrous Ammonium Sulphate. Bacteriological parameters (E. Coliform and Total Coliform) were measured through Quanty Tray Method in this method 100 ml sample was filled in quanty tray and sealed with the help of quanty tray sealer. After then these quanty tray were put on incubator at 35 degrees Celsius for 20-24 hours.

Ammonical-Nitrogen, Nitrate-Nitrogen and Phosphate were analyzed with the help of HACH 2800HR spectrophotometer. For ammonium analysis Nesseler method has followed in this method mineral stabilizer, polyvinyl solution and Nesseler reagent were used. Nitravar 5 powder pillow was used for analysis of Nitrate-Nitrogen. Ammonium Molybded and tin chloride were used for phosphate analysis in the laboratory.

Statistical Analysis: For statistical analysis of collecting results we analyze standard deviation and standard error of means. These are helps to present data precisely and found the meaningful conclusions. When we present data, it should be kept in mind that statistical measures are very important and using adequate statistical measures. In research works, to express the variability; though they measure different parameters, we have used Standard Error of Mean (SEM) and Standard Deviation (SD). To quantify uncertainty in estimate of the mean we used SEM whereas SD indicates dispersion of the data from mean. In knowing the variability within sample, descriptive data should be precisely summarized with SD.

Mathematically, the SD is presented by following formula: -

$$s = \sqrt{\frac{\sum (X - \overline{X})^2}{n-1}}$$

Where:-
s = Standard deviation of sample,
X - Individual value,
$\bar{X}$- Sample mean,
n = Number of samples.
SEM is presented by following formula: -

$$\sigma_M = \frac{s}{\sqrt{n}}$$

σ_M = SEM,
s = SD of sample,
n = Number of samples.

Results

Comparison of quality of wastewater (Before and after treatment) based on water quality parameters: We have seen very significant result of treatment of wastewater through constructed wetland. We have presented the removal efficiency of pollutants of water quality parameters. In these graphs we only compare water quality between before treatment of wastewater and after treatment of treated water through constructed wetland. In these graphs Inlet IBR (Blue Color) reverent domestic wastewater which is produced by villagers of Ibrahimpur village and Pond IBR (Red Color) indicate the treated water which is stored in storage pond.

pH Value: pH value of domestic wastewater of Ibrahimpur has always higher than 7 and lower than 8.5. Number of pH values found near 7.5 to 8. Average pH value 7.18±0.11 was noted during November 2018 to October 2020. We have found average pH value of Pond Water always lower than domestic wastewater entering on constructed wetland and noted the value of pH was 7.18±0.11.6which represent 6.47% removal efficiency of pH.

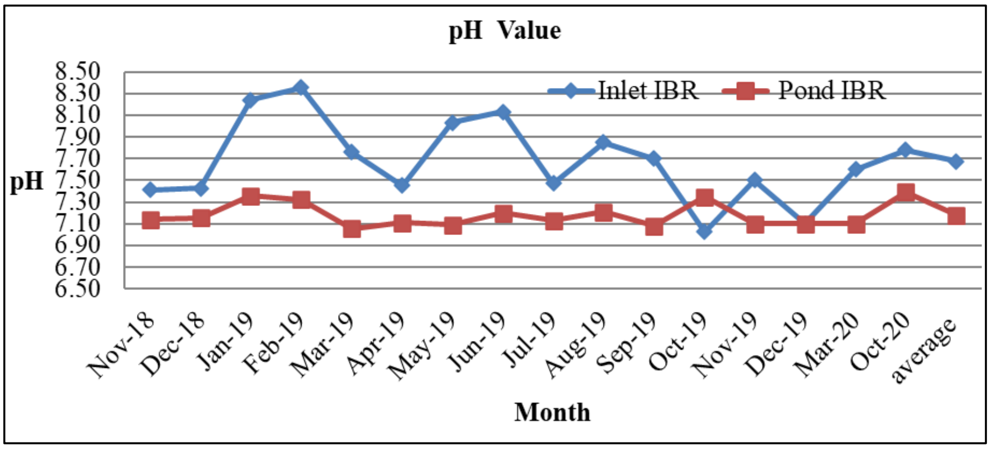

Fig 3: Comparison of pH Value between domestic wastewater and treated water

Electrical Conductivity: Average electrical conductivity of domestic wastewater before entering constructed wetland has found 1820.83±289.68 µs/cm and after passing through constructed wetland average value of electrical conductivity comes 985.30±195.83 µs/cm which represent 45.89% removal efficiency of Electrical conductivity.

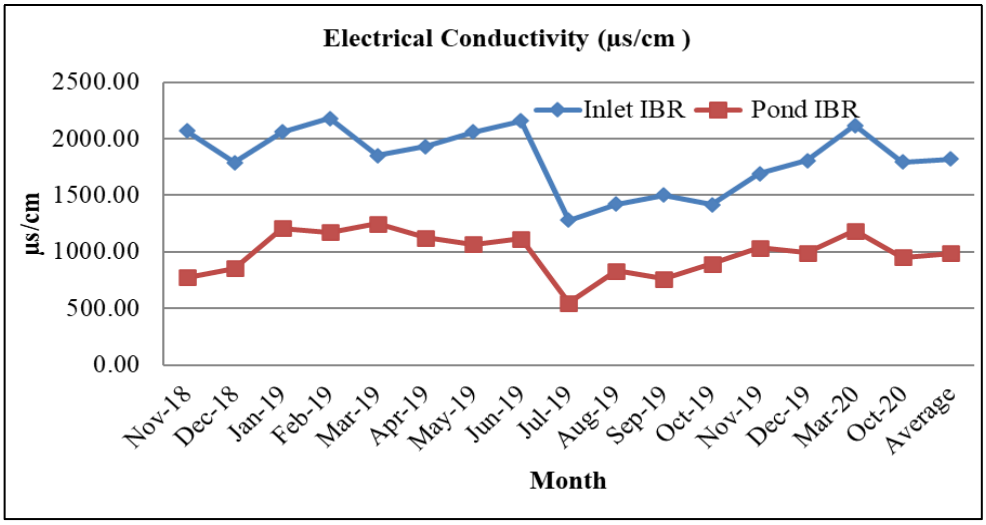

Fig 4: Comparison of Electrical conductivity between domestic wastewater and treated water

Dissolved Oxygen: Average dissolved oxygen of domestic wastewater before entering constructed wetland has found 0.64±0.32 mg/l and after passing through constructed wetland average value comes 5.92±1.68mg/l which represent 824.44% increased dissolved oxygen level on treated wastewater.

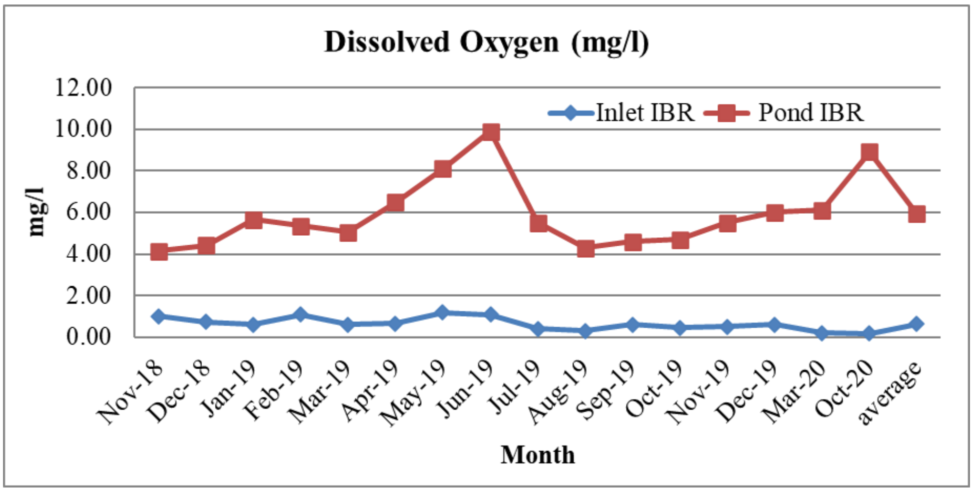

Fig 5: Comparison of Dissolved Oxygen between domestic wastewater and treated water

Biochemical Oxygen Demand: Average dissolved oxygen of domestic wastewater before entering constructed wetland has found 245.31±71.63 mg/l and after passing through constructed wetland average value comes 41.28±7.85mg/l which represent 83.17% decreased biochemical oxygen demand on treated wastewater.

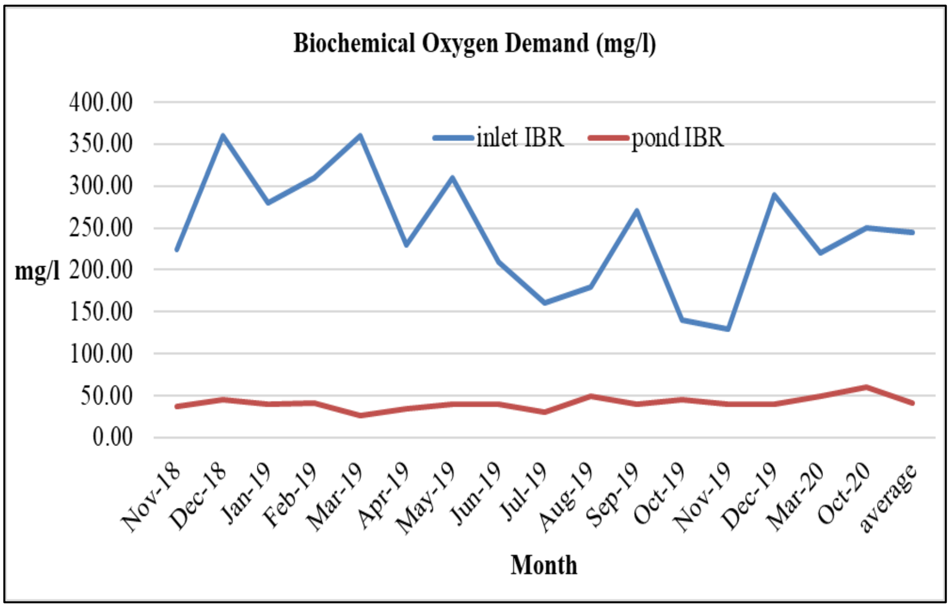

Fig 6: Comparison of Biochemical Oxygen Demand between domestic wastewater and treated water

Chemical Oxygen Demand: Average chemical oxygen demand of domestic wastewater before entering on constructed wetland has found 505.82±147.95 mg/l and after passing through constructed wetland average value comes 96.54±22.98 mg/l which represent 80.92% decreased chemical oxygen demand on wastewater.

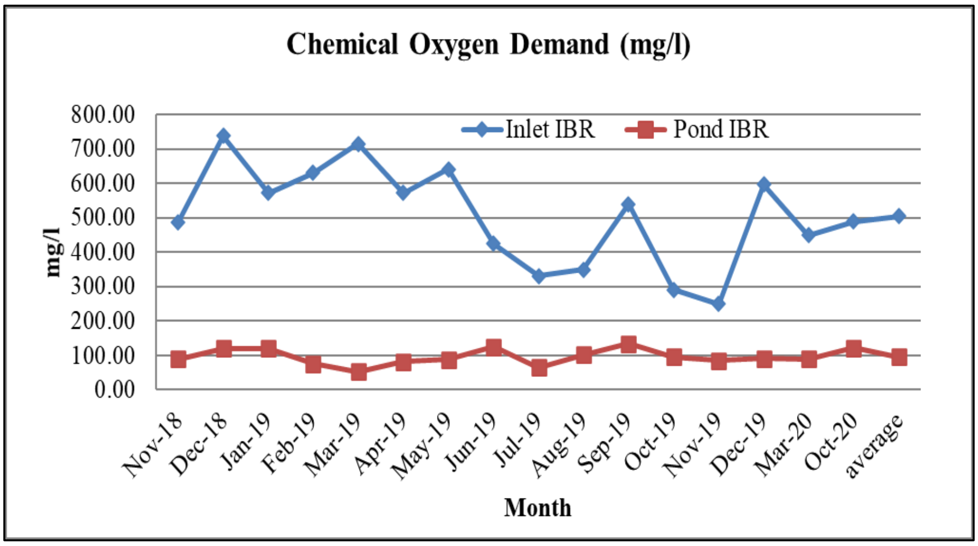

Fig 7: Comparison of Chemical Oxygen Demand between domestic wastewater and treated water

Nitrate-Nitrogen, Ammonical-Nitrogen and Phosphate: Average Nitrate-Nitrogen of domestic wastewater before entering on constructed wetland has found 2.68±1.15 mg/l and after passing through constructed wetland average value comes 1.88±2.68 mg/l which represent 29.93% decreased Nitrate-Nitrogen on wastewater.

Average Ammonical-Nitrogen concentration of domestic wastewater has found 9.42±7.09 mg/l before entering on constructed wetland and after passing through constructed wetland average value comes 1.71±1.91 mg/l which represent 81.01% decreased concentration of Ammonical-Nitrogen on treated wastewater.

Average Phosphate of domestic wastewater has found 3.02±1.50 mg/l before entering on constructed wetland and after passing through constructed wetland average value comes 0.76±0.71 mg/l which represent 74.96% decreased concentration of Phosphate on wastewater.

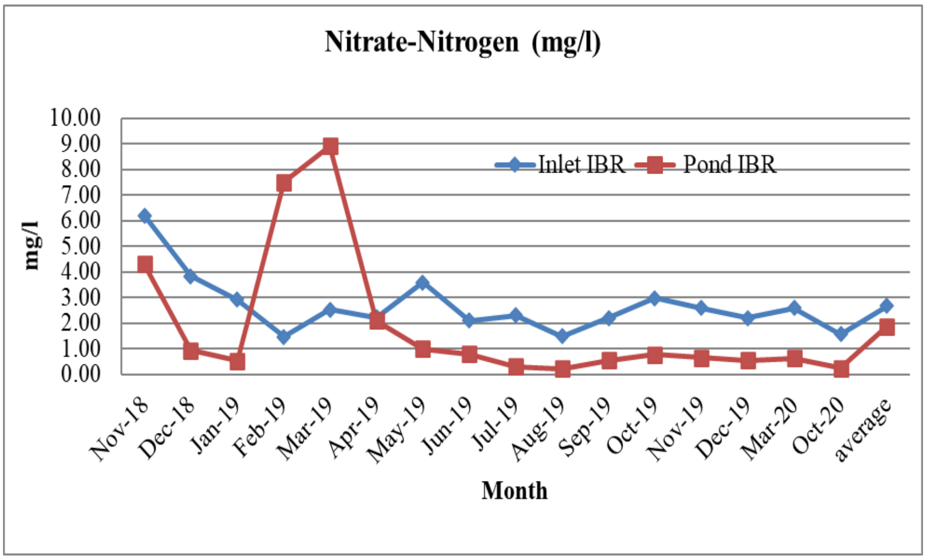

Fig 8: Comparison of Nitrate-Nitrogen Concentration between domestic wastewater and treated water

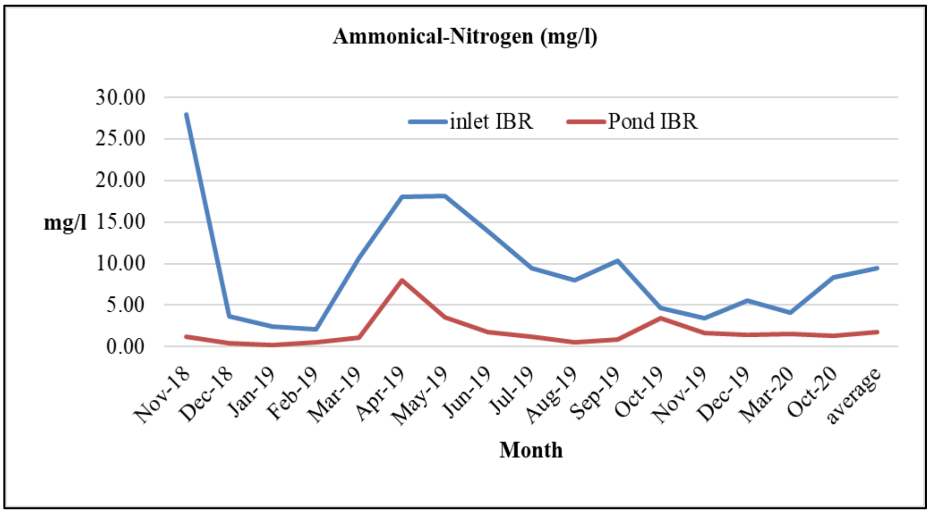

Fig 9: Comparison of Ammonical-Nitrogen Concentration between domestic wastewater and treated water

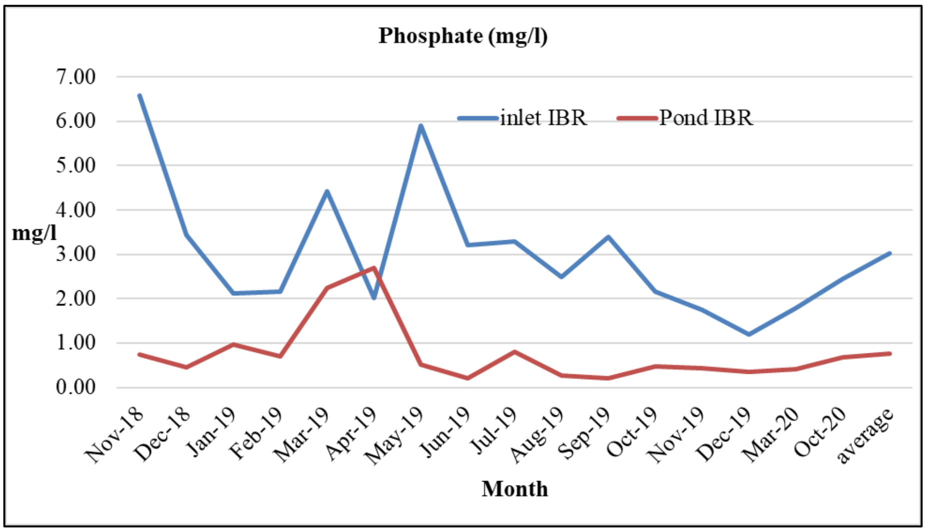

Fig 10: Comparison of Phosphate Concentration between domestic wastewater and treated water

Bacteriological Analysis: Average total coliform (MPN/100ml) of domestic wastewater before entering constructed wetland has found 202401856±186870367 and after passing through constructed wetland average value comes 800848 ±1285634 which represent 99.60% removal of total coliform.

Similarly Average E. coliform (MPN/100ml) of domestic wastewater before entering on constructed wetland has found 10162933 ±14789907 and after passing through constructed wetland average value comes 6308 ±5072 which represent 99.94% increased of E coliform on wastewater.

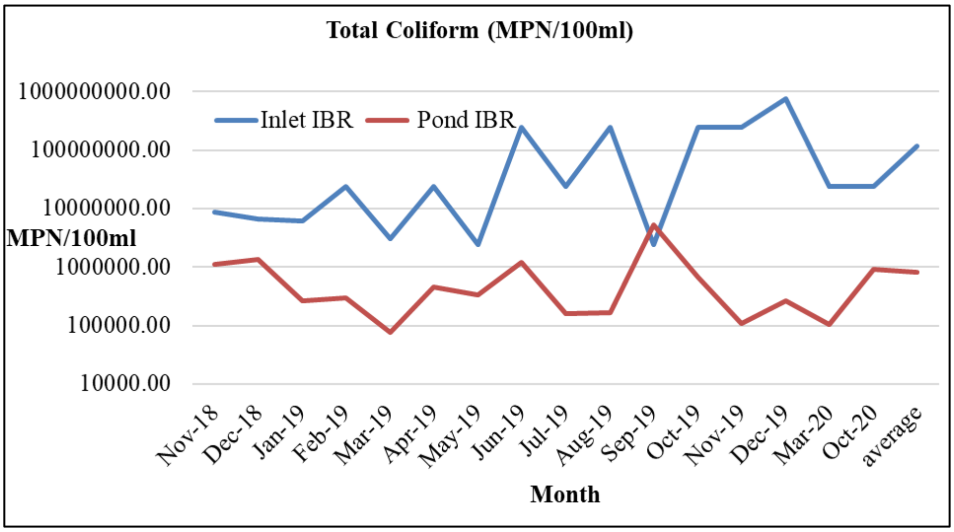

Fig 11: Comparison of Total Coliform between domestic wastewater and treated water

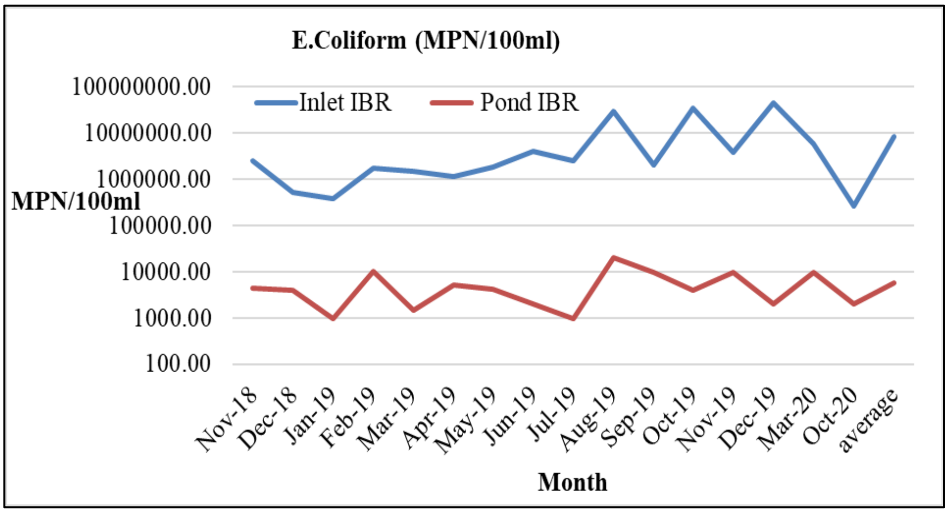

Fig 12: Comparison of E. Coliform between domestic wastewater and treated water

Table 2: Characteristics of water quality parameters before and after wastewater treatment through constructed wetland

Parameter	Samples	Max.	Min.	Average	SD	SEM	Removal Efficiency%
pH Value	Before Treated	8.35	7.03	7.68	0.38	0.10	6.47
	After Treated	7.39	7.06	7.18	0.11	0.03	
Electrical Conductivity (µs/cm)	Before Treated	2178.00	1280.00	1820.83	289.68	72.42	45.89
	After Treated	1247.00	550.00	985.30	195.83	48.96	
Dissolved Oxygen (mg/l)	Before Treated	1.20	0.19	0.64	0.32	0.08	-824.44
	After Treated	9.90	4.15	5.92	1.68	0.42	
Biological Oxygen Demand (mg/l)	Before Treated	360.00	130.00	245.31	71.63	17.91	83.17
	After Treated	60.00	27.00	41.28	7.85	1.96	
Chemical oxygen demand (mg/l)	Before Treated	739.16	250.36	505.82	147.95	36.99	80.92
	After Treated	134.25	52.76	96.54	22.98	5.75	
Total Coliform (MPN/100ml)	Before Treated	770100000	3006500	202401856	186870367	46717592	99.60
	After Treated	5357500	76000	800848	1285634	321409	
E. Coliform (MPN/100ml)	Before Treated	46100000	260300	10162933	14789907	3697477	99.94
	After Treated	20000	1000	6308	5072	1268	
Nitrate-Nitrogen (mg/l)	Before Treated	6.20	1.48	2.68	1.15	0.29	29.93
	After Treated	8.92	0.22	1.88	2.68	0.67	
Ammonical-Nitrogen (mg/l)	Before Treated	27.90	2.13	9.42	7.09	1.77	81.01
	After Treated	8.00	0.19	1.79	1.91	0.48	
Phosphate (mg/l)	Before Treated	6.59	1.20	3.02	1.50	0.38	74.96
	After Treated	2.70	0.20	0.76	0.71	0.18	

In this table - minus sign indicate that value of dissolved oxygen is not decreased while it is increased.

Conclusion

As we saw on above results the water quality parameters in pond water is significant and it represents the performance of constructed wetland so that we can say that this constructed wetland is very helpful to treat domestic wastewater and its reuse may help to solve water scarcity problem in country. In the above results removal efficiency of pH is not high but its average value is 7.18±0.11 which is under permissible limit 6.5 to 8.5. Electrical conductivity was removed 45.89% and noted these reading is 985 µs/cm both these parameters are very important for health as well as irrigation purposes. Dissolved oxygen is also play important role for fish production we found suitable dissolved oxygen in pond water 5.92 mg/l which is indicate that water quality is good for fish production whereas before treatment of wastewater it was 0.64 mg/l. If we saw organic matter removal through constructed wetland, we have found significant removal of organic matter in the form of BOD and COD and noted these removal efficiencies is 83.17 and 80.92% respectively. Constructed wetland also helps to remove coliforms present in wastewater which is harmful for the health and removal efficiency of Total Coliform and E. Coliform was found 99.60 and 99.94% respectively. We found 6308 E. Coliform after treated wastewater that is showed this treated water may not be drinks but this treated water can be used other recreation work and also used for agricultural practices. Removal efficiency of Nitrate-Nitrogen was noted near 29% and note this concentration in 1.88 mg/l after treated wastewater which is under permissible limit of its concentration less than 5 mg/l. Removal efficiency of Ammonical-Nitrogen and phosphate after treated wastewater we found 81 and 75% which is beneficial for health and agricultural purposes. Access concentration of Nitrate-Nitrogen, Ammonical-Nitrogen and phosphate also harmed our soil health as well as human health.

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