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Lab Scale Design and Performance Study of Filter Media: A Potential Application in Irrigation Run off

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Abstract

Presence of nutrients such as nitrogen (N), phosphorous (P), potassium (K) in water bodies majorly contributed by irrigation run off resulting in the prolific growth of aquatic weeds that cause undesirable effects including water flow obstruction, damage of river banks, decrease in the quality of agricultural field and loss of aquatic life. Therefore, it is vital to device novel methods for the removal of N, P, K in irrigation run offs. We established a novel filter media named Multi Filter Media (MFM) using the natural waste material like coconut fifer and paddy husk with course sand of size 4.75 mm to 2 mm and supported by gravel medium. Extensive Experiment prove that 85% to 90% of potassium and phosphorous were successfully removed. Further, 50% of annual maintenance cost of the selected study area of the drainage carrier drain will be reduced, while adopting this method of Multi filter media made up of concrete in the irrigation field.

Keywords: Aquatic Weeds, Irrigation Run Off, Multi Filter Media (MFM), Nutrients, Waste Materials

1. Introduction

The end of the 19th Century *Ipomoea cornea Jacq*. was introduced in India as a garden and hedge plant. It is one of the important types of (emergent weeds) aquatic weeds which were exported from the native of South America[1,2]. It has spread rapidly on land and in water causing obstruction and difficulties in the proper use of the land for cultivation; and in water it affects irrigation, navigation, and fisheries[3]. In other area it grows into dense populations along river beds, embankments, canals and other water logged (wetland) areas and contributes to the mosquito nuisance[4].

The other important type of aquatic weeds in India are: *Eichhornia crassipes* (water hyacinth) (free floating), *Nymphaea stellata* (rooted floating), *Nelumbo nucifera* (rooted floating), *Hydrilla verticillata* (rooted submerged), *Typha angusta* (emergent), *Sagittaria* sp., *Potamogeton* sp.(rooted submerged), *Pistia stratiotes* (free floating), and *Salvinia molesta* (free floating), *Azolla caroliniana*, *Alternanthera philoxeroides*, *Polygonum* sp., *Cyperus* sp., etc[5].

In India, many rivers, irrigation canals, drainages, lakes and tanks are affected by the prolific growth of aquatic weeds, resulting in enormous direct and indirect losses. Eutrophication has led to increasing weed problems in reservoirs[6]. It was reported that in the Chambal Project in India, submerged aquatic weeds had cut the flow of water by 80 per cent in the canals. Vast areas of

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lowland paddy in the north-eastern parts of India and Kerala state are badly infested with aquatic weeds. Most of the fishery tanks and ponds in and around Bangalore and other cities have been badly invaded by water hyacinth. Among the floating weeds, particularly in Punjab, water hyacinth is the main problem. About 40% of fresh water unsuitable for fish production because, of invasion by aquatic weeds. Several irrigation and hydroelectric projects in the country are endangered by infestation of dams and reservoirs with massive growth of aquatic weeds. For instance, Tungabhadra project in Karnataka, Nagrajuna Sager project in Andhra Pradesh, and Kaki and Idikki reservoirs in Kerala are filled with aquatic weeds up to alarming situations. The Bhilai Steel Plant in Madhya Pradesh and the Bokaro Steel Plant in Jharkhand are faced with acute problems of aquatic weeds in their cooling tanks where they prevent proper circulation of water in pipes. Aquatic weeds are a great problem in canal system which has already reduced the designed flow of many of these by 40-50 per cent. The impeded flow of water in canals resulted in forced seepage, water logging and soil salinity[7-9].

In the city of Madras, Velachery tank, boundary of Pallikkaranai drainage swamp, portion of Adayar River, Buckingham canal and Otterinullah have turned eutrophic due to water hyacinth. In Tamil Nadu almost 80% of the 39000 tanks are already infested with this weed. Even very big tanks like Chembarabakkam tank, Dusi-Mamandur tank, Kaveripakkam tank, Veeranam tank etc. are also affected by this weed[10].

Prolific growth of aquatic weeds in the drain or rivers such as water hyacinth, ipomoea cornea is main problem to manage the drainage or irrigation water. They cause the problem likes Hindrance to water transport, clogging of intakes of irrigation, blockage of canals and rivers causing flooding, Micro-habitat for a verity of disease vectors, to increase evapotranspiration, Problem related to fishing, reduction of biodiversity resulting to damage the banks, agriculture field as well as affect the aquatic life[11]. It will also cause the deposition of silt in the bed of Drain and River. Every year huge amount is being spent to remove the Aquatic weeds in the Drain or River especially deltaic region by the Government of Tamilnadu. But the result is not appreciable one. Even though different methods like, mechanical, chemical and biological methods are being practiced to control the aquatic weeds, their outcomes are not good and at the same time as reverse impact, it pollute the water and soil. Cost wise also it is uneconomical one[12].

The main reason for prolific growth of Aquatic weeds due to nutrients mainly Nitrogen (N), phosphorus (P), potassium (K) presents in the surface waters. Even though Erosion, runoff, subsurface drainage, groundwater flow and atmospheric deposition are sources for nutrients in to surface waters, irrigation runoff is the major sources for nutrients. Irrigation runoff carries some inorganic nitrogen, primarily as nitrate and ammonium, generally leached into the soil with precipitation that occurs before runoff begins. However, if a sudden runoff event occurs shortly after surface application of nitrogen, concentration of inorganic nitrogen in runoff may be abnormally high. Growth of aquatic vegetation in fresh surface waters is commonly limited by low concentrations of phosphorus and nitrogen. Increasing of nitrogen and phosphorus in the water resulting increasing of vegetative growth's[13-15].

In this research work, we plan to remove nutrients N, P, and K from the irrigation runoff. Hence the attempt was made to design and study a Lab scale setup of Multi Filter Media (MFM) by using locally available waste materials like paddy husk, coconut fifer and course sand and also to study the possibility of the implementation of such type of MFM concrete structure in the irrigation field to remove the Nutrients from the irrigation runoff which is the root cause for growth of aquatic weeds in the selected area.

2. Materials and Methodology

2.1 Material

The course sand of effective grain size 4.75 mm to 2 mm was used in the filter media which is available in the local sand quarry[16]. The waste materials like paddy husk and coconut fifer are also locally available in the agricultural area with minimum cost[17]. The support medium of gravel is also available within 5 to 10km radius of the required site.

Table 1. Design criteria for lab scale setup of MFM.

Sl. No.	Parameter	Range
1	Size of The MFM	15 Cm X 15 Cm
2	Depth of MFM	50 Cm
3	Rate of Flow	70 Ml/Min
4	Gravel Support Medium	15 Cm Depth
5	Course Sand Size	4.75 Mm To 2 Mm With 15 Cm Depth
6	Coconut Fifer / Paddy Husk	15 Cm Depth

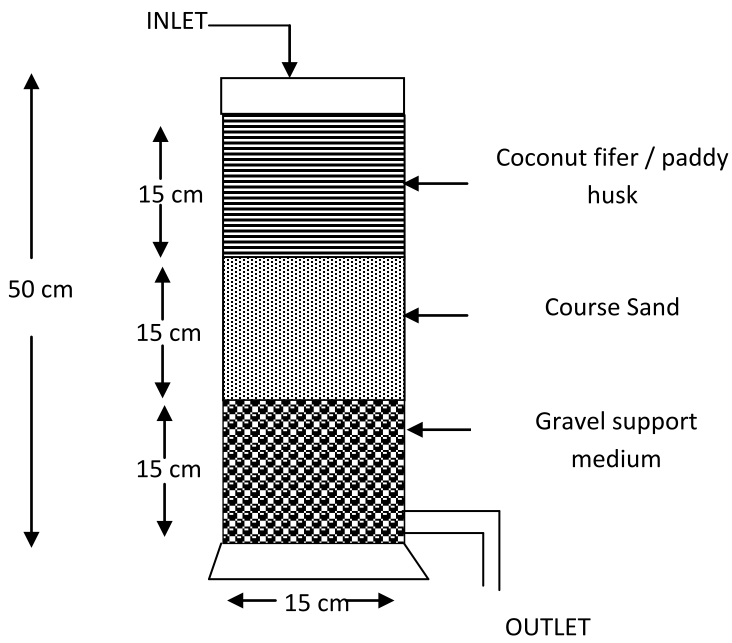

Figure 1. Multi filter media.

2.2 Working Principles of Multi Filter Media (MFM)

A lab scale set up of Multi Filter Media (MFM) likes square sized glass column made up of size 15 cm x 15 cm x 15cm (Figure 1) was established in the Laboratory. This study project was done mainly based on the principle of absorption and adsorption through the multi filter media[18]. The multi filter media containing (Table 1) available natural waste materials like paddy husk (or) coconut fifer along with the course sand size 4.75 mm to 2 mm and gravel support at bottom. The synthetic N, P, K contents water sample was flow through the multi filter media @ 70 ml / minute in such a way and N, P, K values were assessed from the water sample collected at the outlet.

2.3 Working Procedure

The coconut fifer and paddy husk were thoroughly cleaned and washed by water and dried in open place. The gravel medium and course sand also cleaned and dried. Take gravel medium and filled with 15 cm height as a bottom of the multi filter media column as support medium. The course sand of size 4.75 mm to 2.00 mm and filled above the support medium up to 0.15 m height in the multi filter column. The coconut fifer was taken and filled at the top layer of the MFM column at the height of 15 cm. Take 3 liter of water in plastic container and take each 5 gm / lit. Of super phosphate (P), Potash (K) and Urea (N) are thoroughly mixed with water. From the synthetic N, P, K contain water sample, take and keep 1 liter of water sample for access the nutrients N, P, K in the inlet water. The balance 2 liter of water sample in the plastic water container which was placed at top of the MFM column and the water sample was flow through the tube @ 70 ml/minute by gravity into the MFM column. The water sample were collected at the outlet in the 1 liter capacity of plastic bottle after passing through the MFM column for assess the N, P, K values. In the above procedure was repeated for another synthetic water sample containing of each 10 gm/ lit. of each content of urea, super phosphate, potash taken and mixed with water sample. And inlet and outlet N, P, K values were tabulated. The above procedure were also repeated for the MFM column containing waste material of paddy husk, instead of coconut fifer with course sand and gravel medium. These values also were tabulated.

2.4 The Study Area

The study area of 1km reach of Senbagapuram vari drain at L.S 9.2Km (Road bridge) at Arsuthipattu village

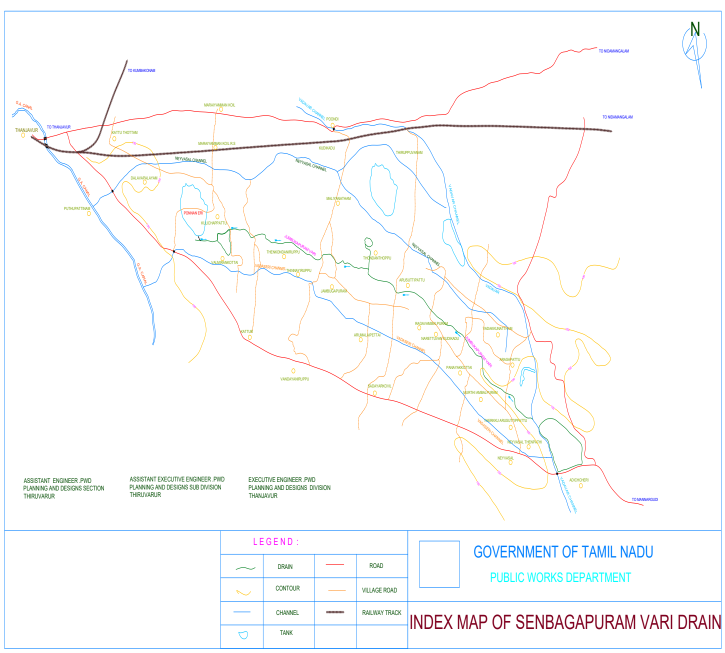

Figure 2. Index map showing senbagapuram vari drain.

(a)

(b)

Figure 3(a) and (b). Growth of aquatic weeds in senbagapuram vari drain.

(Latitude 10^0.44'.58", Longitude 79^0.16'.22") in Thanjavur District of Tamilnadu state was selected to study the possibility of implementation of upscale the lab scale setup by providing the multi filter media (MFM) concrete trough for removal of nutrients from the field irrigation runoff. The senbagapuram vari drain (Figure 2) started from surplus course of ponnen Eri (Latitude 10^0.45'.48", Longitude 79^0.11'.26") and confluence at Vadavar River at vaduvur village (Latitude 10^0.42̇.16", 79^0.19̇.01̈.). The total length of the drain is 14.6km.There are three drainage inlets are in fall at the selected reach of the drain at Arsuthipattu village. The length of the drainage inlets are 1.2km, 1.6km and 2.2km.

The MFM concrete trough was designed as per field condition and estimate the total no's of MFM and total construction with maintenance cost of MFM will be required per year in the three drainage inlets which are in fall at the particular reach of the drain. And also Estimate the regular annual maintenance cost will be required for desilting of the drain and temporary breach closing work during the flood season ,etc, will be carried out in that reach of the drain per year.

2.5 Criteria for Site Selection

- The minimum depth of MFM should be as 0.45m.
- The depth of the MFM constructed site of drain/channel/field should be more than the depth of MFM. i.e.) <0.45m depth.
- The bottom sill level of Agriculture field/channel site which is to be provided for MFM should be higher (at least 0.45m) than the sill level of Drained Chanel (Table 2).

Table 2. Design criteria of concrete trough MFM.

Sl. No.	Parameter	Range
1	Discharge at each drainage Point from the Field	8lit/sec (or) 28m3/hr
2	Size of the MFM	90cm * 90cm*45cm
3	Waste materials used in the MFM	Paddy husk / coconut fifer
4	Nutrient Load capacity	N= 0.00Mg/Lit/cm2 P= 1.36Mg/Lit/cm2 K= 10.77Mg/Lit/cm2
5	Diameter of Inlet &outlet Pipe in PVC	50mm Dia
6	Rate of Flow in the MFM	70ml/min
7	No of Lateral Pipe	74 nos of 5mm dia. pipe@ spacing of 20 mm in both side of main pipe. 90 nos of 2mm dia. Of holes are Provide by Zigzag @ spacing of 10 mm in both side of laterals

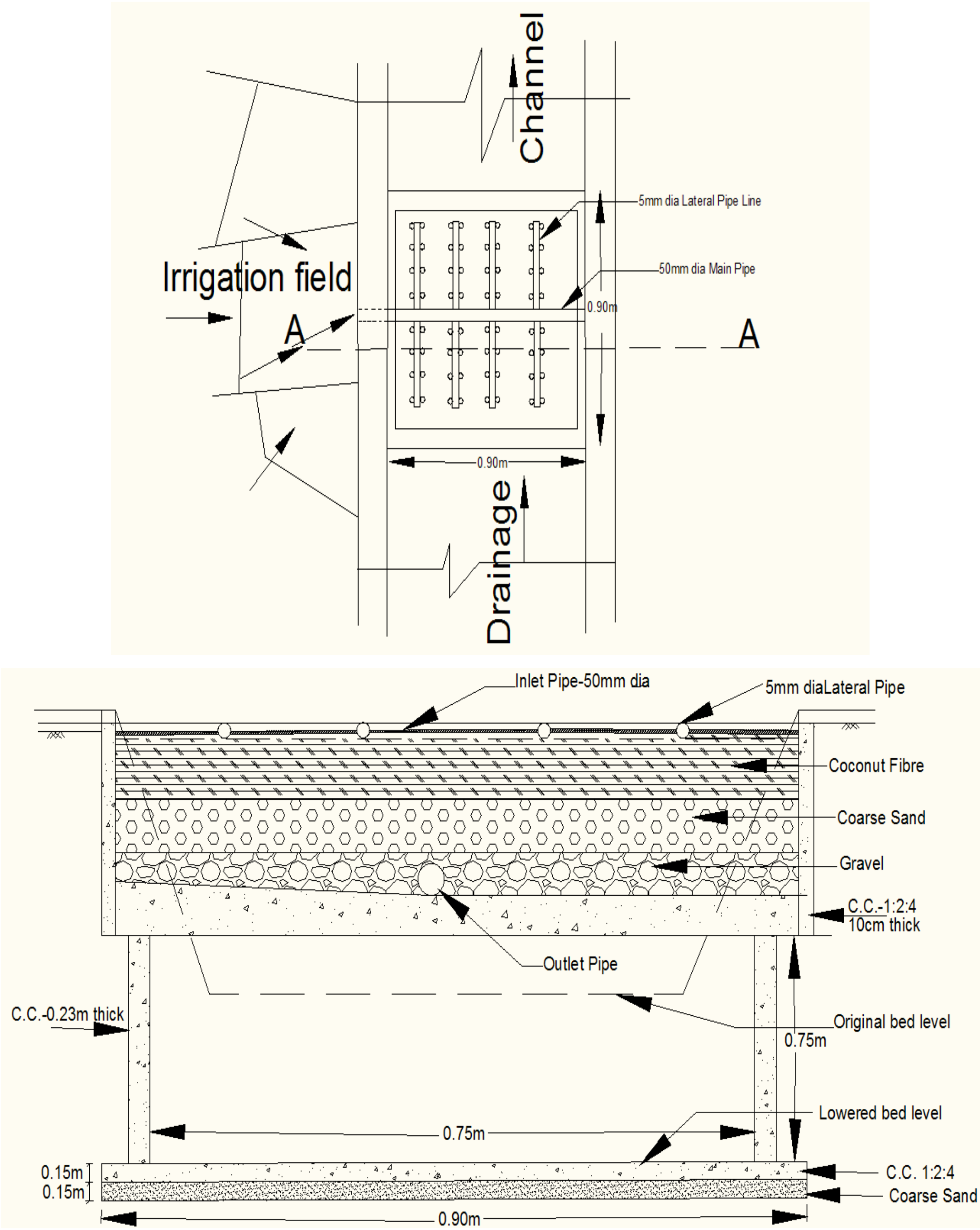

Figure 4. Plan and cross-section of multi filter media concrete trough.

Table 3. Result of filtration with coconut fifer.

Sl. No.	Rate of flow of water with amount of N, P, K contain fertilizer	Absorption media details	Amount of N, P, K present in the water sample			
			Para meter	Inlet (mg./lit)	Outlet (mg./lit.)	% of removal
1.	70ml/min. & 5gm/lit. of each content of fertilizer	15 cm - coconut fifer	N	10	9	10%
		15 cm - course sand	P	315	33	90%
		15 cm - gravel medium	K	2014	171	92%
2.	70ml/min. & 10gm/lit. of each content of fertilizer	10 cm - coconut fifer	N	13	13	0%
		10 cm - course sand	P	631	353	44%
		10 cm - gravel medium	K	4692	2463	48%

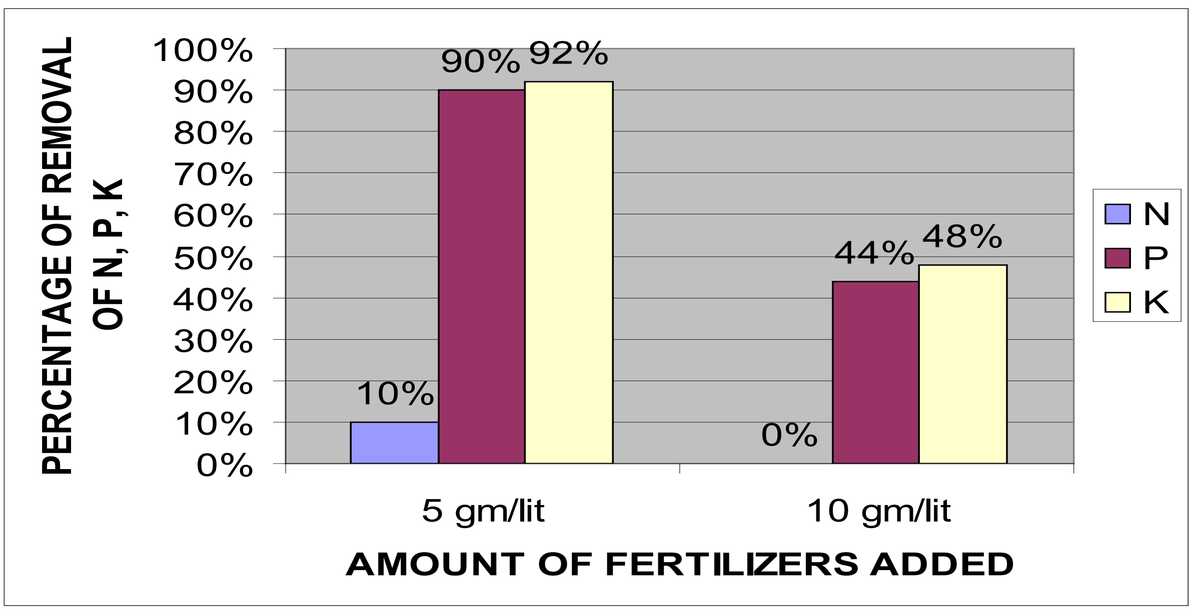

Figure 5. Percentage of Removal of N, P, K using with coconut fifer.

Table 4. Result of filtration with paddy husk.

Sl. No.	Rate of flow of water with amount of N, P, K contain fertilizer	Absorption media details	Amount of N, P, K present in the water sample			
			Para meter	Inlet (mg./lit)	Outlet (mg./lit.)	% of removal
1.	70ml/min. & 5gm/lit. of each content of fertilizer	15 cm - paddy husk	N	8	8	0%
		15 cm - course sand	P	306	44	86%
		15 cm - gravel medium	K	2424	340	86%
2.	70ml/min. & 10gm/lit. of each content of fertilizer	10 cm - paddy husk	N	13	13	0%
		10 cm - course sand	P	727	488	33%
		10 cm - gravel medium	K	4888	3460	29%

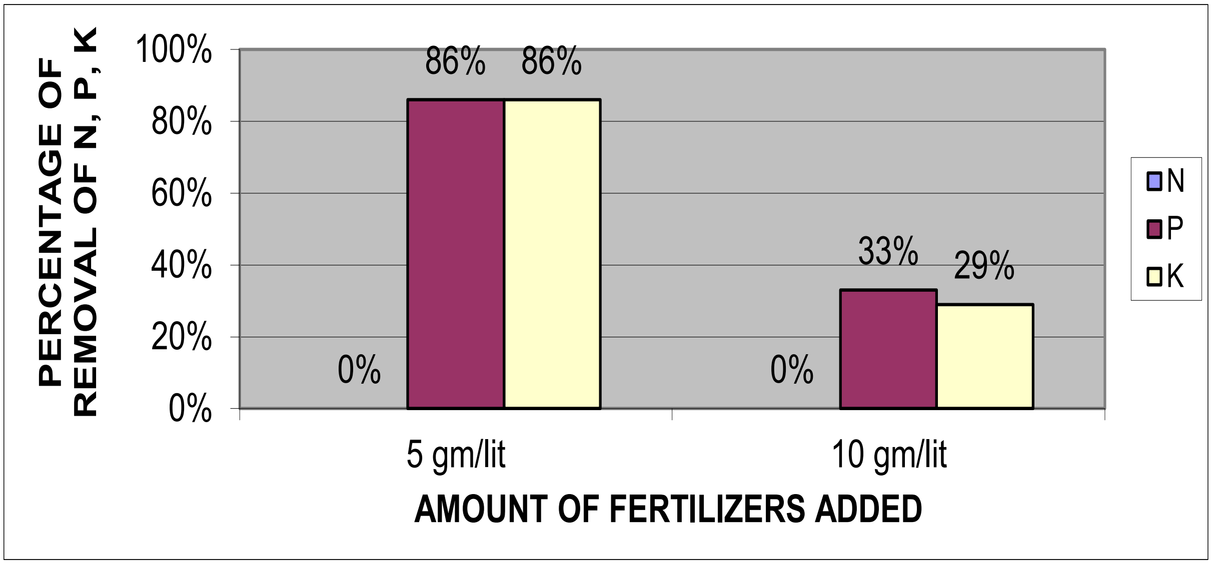

Figure 6. Percentage of removal of N, P, K using with paddy husk.

Table 5. Cost analysis.

Cost of construction and maintenance of concrete trough (MFM) for 10 year/1km						**Cost of other regular maintenance work of the drain for 10 year/ 1km**				
Sl. No	**No of inlet channel**	**Loca-tion**	**Total No of MFM Trough Requi-red**	**Cost of one Trough per /10 year**	**Total cost of MFM Trough/ 10 year**	**Description of work**	**Quan-tity of work**	**Rate of work in Rs**	**amount required for once in three year in Rs.**	**Total amount required for 10 year in Rs.**
1	3 nos	Every 100m Dis-tance	50 nos	30,000	15,00,000	1.Desilting of drain for 1Km by once in three year	17500 m3	40/ m3	700000	21,00,000
2.						2.Temperary breach closing work due to flood	6 nos	5000/ each	3,00,000	900000
			Total	Rs.	1500000			Total	Rs.	3000000

Note: The rate of materials and works are adopted as per schedule of rate 2014-2015 in TNPWD

3. Results and Discussion

Table 3 and Figure 5, the nutrients Potassium (K), Phosphorous (P) are removed from the water sample by using coconut fifer with coarse sand is at maximum (i.e.) 90% and more in the initial stage of experiment with adding of 5 gm / lit of each content of fertilizers. But, there was only 50% of nutrients (Potassium (K), Phosphorous (P)) are removed in the next stage of experiment while adding of another 10gm/lit of fertilizers in each content. Whereas, Nitrogen (N), was still present in the water sample in both stage of the experiment. Hence it is decided to try to use another waste material for efficient removal of nitrogen component. Further it shows that the above filter medium partially removed the nutrients in the next stage of experiment due to clogging of medium. It will be washed frequently by fresh water.

Table 4 and Figure 6, the nutrients Potassium (K), Phosphorous (P) are removed from the water sample by using paddy husk with coarse sand is at maximum (i.e.)85% and more in the initial stage of experiment with adding of 5 gm / lit of each content of fertilizers. But, there was only 30% of removal of nutrients (Potassium (K), Phosphorous (P)) in the next stage of experiment while adding of another 10gm/lit of fertilizers in each content. Whereas, Nitrogen (N), was still present in the water sample in both stage of the experiment. Hence it is decided to try to use another waste material for efficient removal of nitrogen component. Further it shows that the above filter medium partially removed the nutrients in the next stage of experiment due to clogging of medium. It will be washed frequently by fresh water.

Table 5, the Constructing and Maintenance Cost of MFM Trough for one year per 1Km is Rs.1, 50,000 whereas the maintenance cost of drain by carried out by the other method for one year per 1Km is Rs.3, 00,000.It shows about the 50% of annual maintenance cost of the selected study area of 1Km of senbagapuram vari drain will be reduced as compared to the other regular type of annual maintenance work carried out in that reach of the drain.

4. Results

The nutrient of Potassium (K), Phosphorous (P) was removed at 85% to 90% in the water sample by using both coconut fifer and paddy husk waste materials. But the nitrogen (N) remained unaffected by the treatment. The MFM was proved to remove the nutrients of Potassium (K), Phosphorous (P) from the waste water sample at high efficiency with low cost since the waste materials were being used in this MFM are locally available at the minimum cost. The MFM should be washed and cleaned frequently by fresh water due to clogging of solids.

And also the implementation of these method of construction of MFM concrete structure provided in the selected area was possible and 50% of annual maintenance cost of the 1Km of Senbagapuram vari drain will be reduced as compared to the other regular type of annual maintenance work carried out in that reach of the drain. The above Annual maintenance cost of drain will be more reduced, if the farmers are motivated and make awareness among the usage of fertilizers and prevent the pollution of surface.

Further it will prevent the water pollution in and around the area including groundwater, to safeguard the aquatic life, to prevent the spreading of disease by mosquitos and possibility of reuse the same water for agricultural purposes. The only drawback of the MFM is that during flood season it may not work possibly due to submerge.

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