PERFORMANCE ASSESSMENT OF DIFFERENT WATER FILTERING MEDIA

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Abstract – *The article presents the results of research on the performance assessment of different water filtering media. It is an established fact that untreated domestic sewage if directly discharged into a water body, degrades the water quality making it filthy & unhygienic and detrimental for survival of aquatic lives.I felt inclined to opt for a venture which puts a challenge regarding the safe disposal of such untreated water into a stagnum water pond. Also small ponds are devoid of the natural treatment process termed as "self-purification", which further aggravates the problem Under the work the characterisation of pond water was carried out and attached growth microbial treatment with different filter media for the "Trickling Filter", such as khus straw, paddy husk, crushed iron ore, and pulverised coal lumps has been tried. A comparative study in terms of its BOD has been made, to find the economical & feasible filter media for effectual wastewater treatment.In the present work the principle of the conventional trickling filter has been applied and the performance evaluation of different filter media were studied using standard preservation, sampling and analytical procedure. The laboratory setup consisted of the filter tank of 20 litres with filter media put in layers comprising of natural aggregate with sizes varying between 20mm to 600microns as base media of the filter media. The top layer thickness of 7.5cm was replaced with aforesaid mediums during study. The aggregate coal lumps and crushed ore were soaked in seed water (diluted cow dung) for about 24-36 hours prior to its use.The influent and effluent characteristics of water were compared. It could be inferred from the outcome that performance of khus straw filter media was best amongst all. Its prominence is probably due to its dual property, better absorption capability and better microbial attach ability. The treated water was also found to be less turbid, colourless and of lower pH.*

The regeneration of the media is also required to be studied, in order to make it viable and cost effective. Thus it is open that few more media could be tried and compared as per standard methodology prior to declaring the best suiting filter media for making the waste water safe before disposal.

***Key Words*: 1.Stagnum**

1. INTRODUCTION

Waste water is any water that adversely affected in quality by anthropogenic influence. Waste water generated in areas without access to centralized sewer system relies upon site waste water systems. Sewage is the subset of waste water that is contaminated with faeces or urine, but is often used to mean any waste water.

The quality of sewage can be checked and analysed by studying and testing its physical chemical and biological characteristics as given below:

PHYSICAL CHARACTERISTICS:

1. Turbidity
2. Colour
3. Odour
4. Temperature

CHEMICAL CHARACTERISTICS:

1. Total solids, suspended solids and dissolved solids
2. pH value
3. Chloride content
4. Nitrogen Content
5. Dissolved oxygen
6. Bio-chemical oxygen demand

BACTERIOLOGICAL CHARACTERISTICS

1. Bacteria
2. Micro-organisms

2. TREATMENT OPTIONS

When such sewage is discharged in some river stream, floating solids present in it may be washed up on the shore, near the point of disposal, where they decompose and create foul smell and bad odour. The large amount of organic matter present in it will also consume the dissolved oxygen from the river stream in getting oxidised and may decrease the dissolved oxygen of the river, causing fish kills and undesirable effects. The discharged sewage also contaminates the river water with pathogenic bacteria. Hence, even if sewage water contains around 99.9% water, it requires treatment in order to avoid nuisance. Now the method of collecting and disposing societies waste has now been modernised and is replaced by a system, in which these wastes are mixed with water and carried through closed conduits of gravity flow. This mixture of water and waste product is termed as sewage. Sewage includes domestic, industrial, municipal liquid waste products disposed of, usually via a pipe or a sewer (sanitary or combined).

Filtration is commonly the mechanical or physical process or operation which is used for the separation of solids from fluids by interposing a medium through which only the fluid can pass. Oversize solid in the fluids are retained, but the separation is not complete; solids will be contaminated with some fluid and filtrate will contain fine & soluble particles (depending on the pore size and filter thickness). Filtration is also used to describe some biological processes, especially in water & waste water treatment in which undesirable dissolved constituents are removed by adsorption & filtration into a biological film grown on or in the filter medium.

The water is fed at the top of a container through a "header" which distributes the water evenly. The filter "media" starts with fine sand on the top followed by coarser sand in a number of layers followed by gravel on the bottom, in gradually larger sizes. The top sand physically removes particles from the water. The job of the subsequent layers is to support the finer layer above and provide efficient drainage.Furthermore the top layer of the filter medium is scrapped out and different types of filter mediums desired to be experimented upon are placed over the existing firm base of gravels and coarse aggregate.

3. PROCEDURE OF SAMPLING:

The physical and chemical characteristics of sewage vary from top to bottom of sewage depth, as well as with time as from morning to evening. It there becomes difficult to obtain a truly representative sample. Samples are taken at a point beneath the surface where the turbulence is thoroughly mixing up the sewage particles. This is called a grab sample. Such grab samples are collected at regular intervals during a day. These mixed samples are mixed together, and the amount utilised from each specimen is proportional to the rate of flow at the time the specimen was collected. This composite sample is taken for testing, as it represents more nearly, the average true strength of the sewage.

3.1 Standard Sampling Methods

A sample has to be representative and valid both in time and space. The parameters in the sample at the time of analysis should have the same values as those at the time and place of sampling.

3.1.1 General equipment:

Use only specified equipment, including sample containers and other sampling equipment. In particular, laboratory supplied containers must be used as specified or else the use of alternative sample containers or sampling methods will make the sample unusable and the laboratory may reject incorrect samples.

3.1.2 Equipment calibration, cleaning and maintenance:

Ensure that sampling equipment is clean and is maintained in good working order before use and at the end of sampling. Keep some spare deionised/distilled/filtered water for this purpose. Equipment must be cleaned periodically to prevent a build-up of dirt. To do this:

1 rinse the equipment well in tap water
2 clean with De-Con 90 (a phosphate free detergent)
3 rinse well with tap water
4 rinse three times with de-ionised water
5 allow drying.

There are different sampling methods adopted for different tests carried out on waste water samples, which are shown as follows:

A. **For chlorides**
Sampling procedure for chloride was followed as depicted in IS 3025(PART-32) 1988.
B. **For turbidity**
Sampling procedure for turbidity was followed as depicted in IS 3025(PART-10)1984.
C. **For Ph**
Sampling procedure for pH was followed as depicted in IS 3025(PART-10)1984.
D. **For odour**
Sampling procedure for odour was followed as depicted in IS 3025(PART-5)1983.
E. **For colour**
Sampling procedure for colour was followed as depicted in IS 3025 (PART-4)1983.

Sampling and its collection method was adopted as per the guidelines available. Sampling was carried out for 7 days continuously. Representative samples were collected from each inlet and outlet. Collected in a cleaned container and preserved according to the standard methods brought to the laboratory for the study of the physical-chemical characteristics.

3.2 filter media:

3.2.1 Filter media characteristics:

The filter media used in the biological trickling filter possess several characteristics. These important characteristics are depicted as follows:

1. **Chemical reactivity**: Chemical reactivity refers to the easiness with which a chemical compound tends to react when it comes into contact with other compounds. The media which we are using for filtering purpose should have lesser chemical reactivity to the sewage water.
2. **Porosity**:Porosity or void fraction is a measure of the void spaces in a material, and is a fraction of the volume of voids over the total volume, between 0 and 1, or as a percentage between 0 and 100%. As we know, more the porosity, more will be the absorption capacity of the filtering media.
3. **Occurrence of filter flies** The growth of bio film over the filter media and the ponding of water inside the filter attract and hearten the occurrence of filter flies which thrive in the damp environment

inside the filter. But filter media like coal lumps are not conducive for the growth of filter flies like psychoda.

4. **Wetting characteristics**:The filter media taken should get easily drenched by water passing over it so that the water may come in contact with the filter media. If the filter media is hydrophobic and does not allow the water to wet its surface then the effective treatment of water by the biological process of breakdown of organic matter will be difficult to come about.
5. **Surface for growth of microbial layer:**The surface of the filter media should be rugged enough so as to hold the bio film layer on it for sufficient time. On the other hand it should be smooth enough to easily get rid of the slime layer when it is washed and does not encourage the growth of thick layer of the bio film.
6. **Specific area**: The ratio of surface area to the volume of the filter media is referred to as its specific area. Any media used for the purpose of biological filtration should have a high specific area for fulfilling the action of adsorption and providing surface for growth of the slime layer.

3.2.2 Filter media characterization:

Table 1

FILTER MEDIA / FILTER MEDIA CHARACTERISTICS	Sand	Khus straw	Paddy husk	Crushed ore	Coal lumps
CHEMICAL REACTIVITY	medium	None	none	high	low
POROSITY	Good	High	good	Very less	good
WETTING CHARACTERISTICS	Good	High	Very less	none	good
OCCURRENCE OF FILTER FLIES	medium	High	high	less	none
SURFACE FOR GROWTH OF BIOFILM	Firm	Good	Smooth and slippery	Firm and rugged	Adsorbent

4. Laboratory Set up

4.1 Filter, dosing and storage tank:

The filter tank comprises of a plastic cylindrical tank of 26cm diameter and 50cm height. The walls of the tank are covered with cotton plugs in order to avoid any short circuiting down the walls of the filter. The store level of water at the bottom of the tank is 10cm below the level of filter media. A freeboard of 10cm is kept at the top above the filter media. The total height of filter media in the tank is 30cm

The dosing tank is a semi spherical bucket of capacity 3litres.It consists of pores placed in a scattered manner at the base of the bucket so as to uniformly distribute the water over the filter media at the top of the filter tank. The hydraulic loading was maintained at approx. 34litres/m^2/hour.

The storage tank is again a cylindrical bucket in which an aerator is fitted which inducts air in form of diffused bubbles at the rate of 3.8mg/l. The storage tank stores the effluent coming out of the filter tank for about 24hours before it gets discharged into some dilution source so as to bring the level of dissolved oxygen in the effluent to a min threshold level. The purpose of aerating the filter effluent is to ensure that the discharge contains dissolved oxygen that would suffice the oxygen requirements of the aquatic species present in the pond.

The dosing tank is placed over the top opening of the filter tank. The influent waste water which is not subjected to any kind of pre-treatment is filled up in the dosing bucket up to the brink and the waste water trickles down into the filter tank.

Similarly at the outlet end of the filter, a store level is created at the bottom of the filter tank so that the water accumulated after trickling down the filter media gets stored before coming out of the tank via an outlet duct placed at the bottom surface of the filter tank. The outlet pipe carries the water into the storage tank placed at a lower level than that of the filter tank. Inside the storage tank an aerator with single hose is placed which introduces diffused air into the accumulated water. The water is aerated for a predetermined time period before a sample of the treated water is taken out for checking out the level of dissolved oxygen in it.

4.2. PREPARATION OF FILTER MEDIA:

- All the filter media were collected and stored before the commissioning of the filter.
- Sieving was done to obtain a good blend of different sizes of aggregate and sand. Standard sieves of 20mm, 16mm, 12.5mm, 10mm, and 4.75mm were used for sieving coarse aggregates and gravel.
- Sieves of 2.36mm, 1.18mm, and 600microns were used for grading the fine aggregate that is sand.
- The graded aggregates, sand, khus straw, paddy husk, crushed ore, and coal lumps were properly washed, oven dried and dressed to be placed as layers of the filtering unit.
- Seeding of the aggregates, crushed ore and coal lumps was done by soaking them in diluted cow dung for about 24 hours so that the filter media are saturated with microbes and can effectively start the treatment without any delay. In this way

maturation time is reduced and effect of microbial treatment can be seen from the first cycle itself.

4.2.1 Arrangement of filtering media in layers:

- A welded cylindrical stand was placed at the base over which the layers of the filter media were piled. This would allow the water to be collected in the under drains before coming out of the filter unit.
- The top of the cylindrical mould was covered with steel wire mesh followed by cotton sheet to avoid any fine suspended particle from reaching the lower store level.
- Over this prepared base the dressed aggregate of size 16 to 20 mm size aggregate was placed for a height of 2.0 cm and 4.5 kg in weight.
- After that a layer of 12.5 to 16 mm size aggregate was placed for a height of 3.0 cm and weight of 2.5 kg.
- The next layer was of 10 mm to 12.5 mm size aggregate placed for a height of 2cm and 1.3 kg weight.
- The next layer was of 4.75mm to 10 mm size aggregate placed for a height of 2cm and 2.2 kg weight.
- The next layer was of gravels of less than 4.75mm size aggregate placed for a height of 2cm and 1.8 kg weight.
- After placing the gravels evenly for the requisite height a cotton sheet was placed over it to prevent the overlying materials from penetrating downwards and clogging the voids formed between the aggregate which is important from purification point of view.
- Upon the cotton cloth was sand of sizes ranging from 2.36 to 4.75 mm sited and evenly spread to a height of 1.1cm and weight 1.7 kg.
- Then a layer of sand of size ranging from 1.18mm to 2.36 mm positioned for a height of 2.4 cm and 2.32kg of weight.
- Next to it a layer of sand size range from 600 microns to 1.18mm positioned for a height of 3.5 cm and 3.2kg of weight.
- Furthermore a layer of sand of size range 300 μ to 600 μ was placed for a height 4.25 cm of and 4.13 kg of weight.
- Then second top layer of size range 300 μ to 150 μ was placed for a height of 5.2cm and of 4.92 kg of weight.
- The top 7.5cm of the total height of the filter media to be placed was reserved for various types of the filtering materials chosen for the treatment and are placed in turns with the remaining height below it comprising of the same layers as already laid.
- To reduce the chances of short circuiting along the walls of the filter tank, we placed thick plugs of cotton cloth circumferentially at each level of the different filter mediums.
- Between the coarse and fine sand layer we place a cotton layer to avoid mixing up of fine sand with coarser ones and hence the increase in the grading of materials down the filter is maintained.

Fig 1.Preparation of Sampler

4.2.2 Fixing the depth of filter media:

1) Immediately below the filter-skin lies the zone in which purifying bacteria abound. The thickness of this zone is usually between 0.3m and 0.4m, the latter if the sand grains are relatively coarse and the filtration rate is reasonably high.

2) Below the depth mentioned above, chemical reactions take place in what may be described as the mineral oxidation zone, within which the organic materials liberated by the bacterial life-cycle in the upper sand layer are chemically degraded. The thickness of this zone may be between 0.4 and 0.5m; the latter when the raw water has a high organic content. Under no circumstances should the total bed thickness of 1 and 2 be less than 0.7m.

3) Continuous sedimentation and straining of particles will gradually increase the resistance in the filter skin, and after one to three months the resistance becomes too high for the filter to produce sufficient safe water. Filtration capacity can be restored by cleaning the filter, which is done by draining off the supernatant water and removing the top 1-2 cm of the sand bed, including the filter skin. This material is not immediately replaced, and on re-starting the filter, the whole filtration process takes place at the same depth below the new surface, i.e. 1-2cmlower in the same bed. Only after the filter has been operating in this way for some years will the bed surface be brought back to its former level by addition of new material. Provision must therefore be made in the original thickness to allow for successive cleanings during this period. In a filter having an average run of two months between cleanings, some 9-10cm will be removed each year, and an allowance of an additional 0.5m of thickness will allow for five years of operation before re-sanding becomes necessary. Taking the above three factors into consideration, a filter-bed of thickness 1.2-1.4mshould be provided at the initial stage

4.2.3 Under drain system:

For under drain system, we placed a strong steel net at a distance of about 8 cm above the base, and above that net the gravel and the sands were placed. At the near bottom of the welded base we made an outlet that joins another pipe meant for storing the clean water.

Table 2 Layer-wise arrangement of media:

Filter media with size	Depth from bottom
Gravel (16-20mm)	2cm
Gravel (12.5-16mm)	3cm
Gravel (10-12.5mm)	2cm
Gravel (4.75-10mm)	2cm
Gravel (<4.75mm)	2cm
Sand (4.75-2.36mm)	1.1cm
Sand (2.36-1.18mm)	2.4cm
Sand (1.18mm-600μ)	3.5cm
Sand (600-300 μ)	4.25cm
Sand (300-150 μ)	5.2cm
Experimental layer	7.5cm

5. Observation table:

The performance of each kind of purifying media was evaluated based on its B.O.D removal capacity and its duration of effective functioning before regeneration has to be resorted to.

For BOD removal

Taking dilution factor=20,
Sewage water is taken to 15 ml and is diluted with distilled water to make it 300 ml.

Table 3 USING FIRST FILTER MEDIA: SAND AND GRAVEL

CYCLE NOMBER		BEFORE TREATMENT				AFTER TREATMENT		
	Ph(i)	DO(I)	DO(F)	BOD	Ph(F)	DO(I)	DO(F)	BOD
1	8.8	7.5	5.1	48	7.3	9.0	6.8	44
2	8.5	7.5		48	7.3	8.8	6.8	40
3	8.6	7.6	5.2	48	6.8	8.4	6.6	36
4	8.7	7.7	5.3	48	6.7	8.2	6.6	32
5	8.8	7.5	5.1	48	7.1	7.3	5.5	36
6	8.5	7.4	5.0	48	7.2	7.2	5.3	38
7	8.5	7.6	5.2	48	7.4	7.0	5.0	40
8	8.6	7.5	5.1	48	7.4	6.8	4.8	40

Table 4 USING SECOND FILTER MEDIA: GRAVEL-SAND-KHUS STRAW

CYCLE NOMBER		BEFORE TREATMENT				AFTER TREATMENT		
	Ph(i)	DO(I)	DO(F)	BOD	Ph(F)	DO(I)	DO(F)	BOD
1	8.8	7.5	5.1	48	7.2	10.0	7.8	44
2	8.5	7.5		48	7.2	9.8	7.8	40
3	8.6	7.6	5.2	48	7.1	9.1	7.4	36
4	8.7	7.7	5.3	48	6.9	8.5	7.0	30
5	8.8	7.5	5.1	48	6.7	7.6	6.6	20
6	8.5	7.4	5.0	48	6.7	7.6	6.4	24
7	8.5	7.6	5.2	48	6.8	7.4	6.2	24
8	8.6	7.5	5.1	48	7.0	7.2	5.8	28

Table 5 USING THIRD FILTER MEDIA: GRAVEL-SAND-PADDY STRAW

CYCLE NOMBER		BEFORE TREATMENT				AFTER TREATMENT		
	Ph(i)	DO(I)	DO(F)	BOD	Ph(F)	DO(I)	DO(F)	BOD
1	8.8	7.5	5.1	48	7.8	68.5	6.2	46
2	8.5	7.5		48	7.8	8.2	6.0	44
3	8.6	7.6	5.2	48	7.7	8.0	6.0	40
4	8.7	7.7	5.3	48	7.9	7.7	5.8	38
5	8.8	7.5	5.1	48	8.0	7.4	5.4	40
6	8.5	7.4	5.0	48	8.0	7.3	5.2	42
7	8.5	7.6	5.2	48	8.1	7.4	5.2	42
8	8.6	7.5	5.1	48	8.3			44

Table 6 USING FOURTH FILTER MEDIA: GRAVEL-SAND-COAL LUMPS

CYCLE NOMBER		BEFORE TREATMENT				AFTER TREATMENT		
	Ph(I)	DO(I)	DO(F)	BOD	Ph(F)	DO(I)	DO(F)	BOD
1	8.8	7.5	5.1	48		9.7	7.6	42
2	8.5	7.5		48		9.0	7.2	40
3	8.6	7.6	5.2	48		8.6	7.0	36
4	8.7	7.7	5.3	48		7.9	6.5	32
5	8.8	7.5	5.1	48		7.3	6.2	28
6	8.5	7.4	5.0	48		7.0	5.8	22
7	8.5	7.6	5.2	48		7.0	5.6	24
8	8.6	7.5	5.1	48				28

Table 7 USING FOURTH FILTER MEDIA: GRAVEL-SAND-CRUSHED ORE

CYCLE NOMBER		BEFORE TREATMENT				AFTER TREATMENT		
	Ph(i)	DO(I)	DO(F)	BOD	Ph(F)	DO(I)	DO(F)	BOD
1	8.8	7.5	5.1	48		8.7	6.5	44
2	8.5	7.5		48		8.6	6.4	42
3	8.6	7.6	5.2	48		8.4	6.2	40
4	8.7	7.7	5.3	48		8.0	5.9	36
5	8.8	7.5	5.1	48		7.6	5.9	34
6	8.5	7.4	5.0	48		7.4	5.7	34
7	8.5	7.6	5.2	48		7.4	5.6	36
8	8.6	7.5	5.1	48		7.3	5.4	38

Graphs

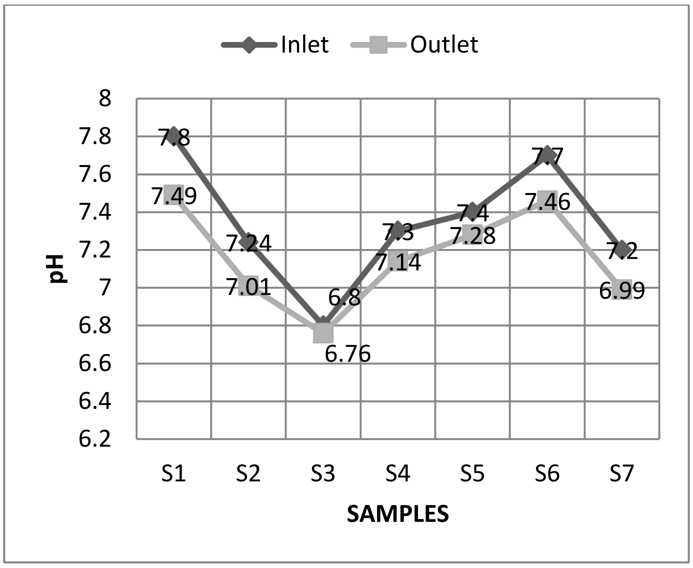

Chart 1 pH

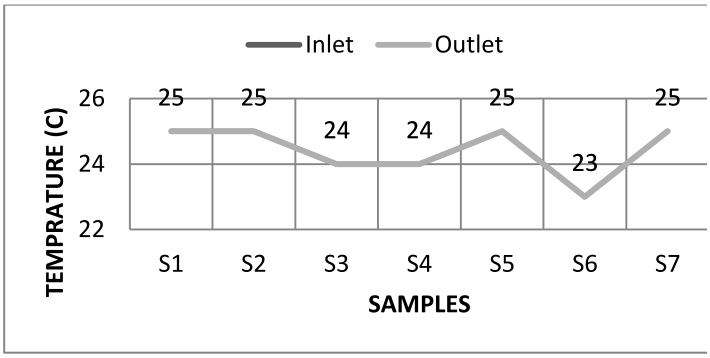

Chart 2 TEMPRATURE

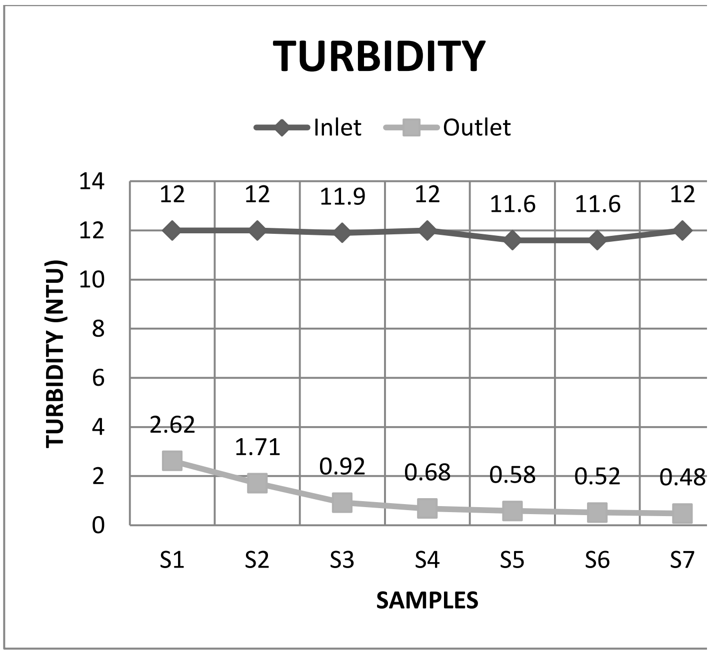

Chart 3 TURBIDITY

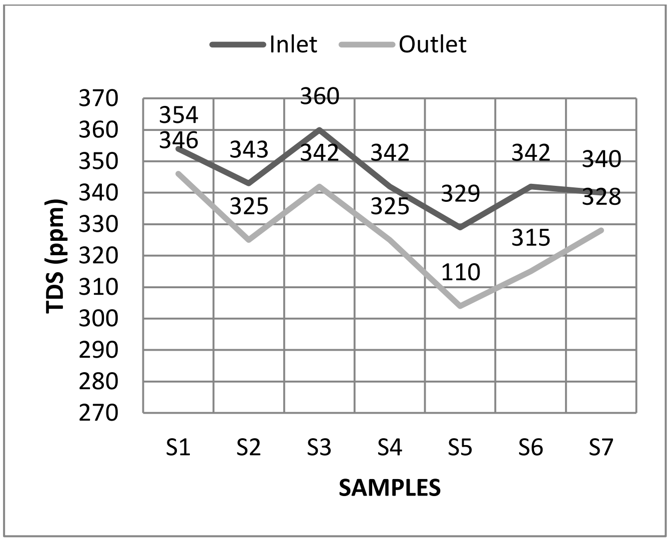

Chart 4 TOTAL SOLIDS

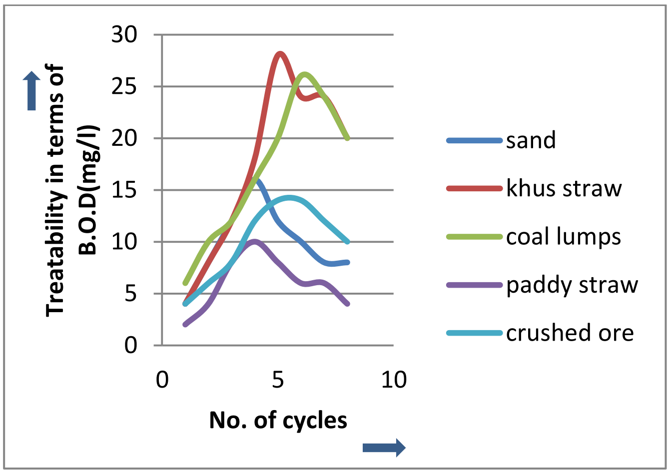

Chart 5 BOD TREATIBILITY OF DIFFERENT FILTER MEDIA

6. CONCLUSIONS

- From the comparative analysis and the study done for evaluation of the performance of various kinds of materials as filtering media, it has been inferred that khus straw proved to be the media which could effectively remove 0`% to 58.33% BOD, paddy straw removes 0% to 20.83% BOD, crushed ore removes 0% to 29.16% BOD and coal lumps removes 0% to 54.17% BOD. There order of BOD removal in decreasing order is given as follows:

  2nd Filtering media> 4th filtering media> 5th filtering media> 1st filtering media> 3rd filtering media
- Moreover based on duration before **regeneration** is necessitated it is concluded that 1st filter media (sand-gravel) requires regeneration after cycle, 2nd filtering media (sand-gravel-khus straw) requires regeneration after 5th cycle, 3rd filtering media (sand-gravel-paddy straw) requires regeneration after 4th cycle, 4th filtering media (sand-gravel-coal lumps) requires regeneration after 6th cycle and 5th

filtering media (sand-gravel-crushed ore) requires regeneration after 6th cycle. There order of regeneration required:

- However **chloride** parameter was observed to remain unaltered.
- **Turbidity** removal of these filtering media is more or less resembles to each other.

From the above available data it is inferred that 2nd filtering media () & 4th filtering media is found to perform better probable due to better **adsorption character**. These filtering media has better rugged surface due to which growth of **biological film** on these filtering media is more as compare to remaining filtering Medias**.**

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