Efficiency assessment of Sand Intermittent Filtration Technology for waste water Treatment

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ABSTRACT

In the modern industrialized world Wastewater treatment is a burning issue. Conventional sewage treatment technology is often unsuitable for many applications in developing countries. The present study was undertaken to assess the efficiency and pollution reduction potential of Sand intermittent filtration technology in term of physico-chemical characteristics of effluent collected from an industrial area. The waste water was filtered through Sand intermittent filtration beds of mixture of sand and gravel at different ratio i.e. 1:1; 1:2; 2:1 and one set of 100% of sand were also taken. In general sand and gravel beds have shown better performance than only sand bed for waste water treatment. Mixture of Sand and gravel bed at ratio 2:1 has yielded better results in general than all other used ratio. Maximum percentage reduction (%) in different physico-chemical parameters such as pH, TS, TDS, TSS, DO, BOD, COD, Chloride, Total Hardness (TH), and Calcium Hardness (CaH) was observed 6.15%, 42.39%, 44.02%, 46.26%, 59.65%, 23.41%, 94.00%, 32.99%, 34.02%, 51.41%, 52.28% respectively. In all the experimental setups maximum percentage reduction was observed at 30 cm width of filtration bed.

Keywords: Sand intermittent filtration, biolayer, relentless pressure, economic technique, filter bed, percentage reduction.

I. INTRODUCTION

Water is becoming a rare resource in the world. In India alone the International Water Management Institute (IWMI) predicts that by 2025, one person in three will live in conditions of absolute water scarcity [1]. Water, food and energy securities are emerging as increasingly important and vital issues for India and the world.Water as resources is under relentless pressure due to population growth, rapid urbanization, large scale industrialization and Environmental concern.The conservation of a better living environment requires fighting against all forms of environmental pollution.

In India it is estimated that more than $8642X10^6$ $m^3$of wastewater is generated per annum from 212 class I cities and 241 class II towns. Only 23% of wastewater is being treated mostly at primary level prior to disposal and 77% untreated water is discharged on land [2].Efforts have been made by the government of India force to setup the treatment plants in different parts of country for the proper and efficient treatment of domestic sewage. But these treatment plants consume lots of energy and require more money for its maintenance. Economy of developing country like India is not so good to afford such types of expensive treatment plants. Besides these irregular power supply and labours problem has affected the working and efficiency of the treatment plants. During 2015, the estimated sewage generation in the country was 61754 MLD as against the developed sewage treatment capacity of 22963 MLD.Because of the hiatus in sewage treatment capacity, about 38791 MLD ofuntreated sewage (62% of the total sewage) is discharged directly into nearbywater bodies (Fig-1). The industrial effluents constitute one of the main sources of the environment degradation [3]. According to CPCB 275 rivers out of 445 rivers monitored under National Water Monitoring Programme are identified as polluted [4]. This condition of Indian rivers is just because of the release of untreated industrial and domestic waste water directly in to rivers.

According to Central Pollution Control Board, 193 Common Effluent Treatment Plants (CETPs) are installed in the country with combined capacity of 1474 Million Litres per Day (MLD). There are 920 Sewage Treatment Plants (STPs) in different States/UTs out of which, 615 STPs are operational, 80 STPs are non-operational, 154 STPs are under construction and 71 STPs are under planning stage. The conventional wastewater treatment processes are expensive and require complex operations and maintenance. It is estimated that the total cost for establishing treatment system for the entire domestic wastewater is around Rs. 7,560 crores [5], which is about 10 times the amount which the Indian government plans to spend [6]. Table 1 illustrates the economics of different levels of treatments through conventional measures [7]. Insufficient capacity of waste water treatment and increasing sewage generation pose big question of disposal of waste water [8]. The reuse of wastewater is a valuable economical source of water in developing countries like India.

Sand filtration is one of the earliest forms of potable water treatment and remains an important process for water purification throughout the world [9]. Simplicity and low cost capital and operating cost are principal advantages of sand filtration compared with more sophisticated methods of water treatment. Keeping in view of the facts present investigation was undertaken to find out the treatment efficiency of sand intermittent filtration technology for waste water treatment. A lot of work has been done in other countries by different authors but in India very little work [10],[11],[12] has been done on sand intermittent filtration.

Renewed interest in SSF has focused on redesign to fulfil the demand for uncomplicated, effective water treatment for small, rural, and remote communities. These modifications in the design increase treatment efficiency and magnify the range of applicable raw water quality. Filtration can be compared to a sieve or micro-strainer that traps suspended material between the grains of filter media. However, since most suspended particles can easily pass through the spaces between grains of the filter media, straining is the least important process in filtration. Filtration primarily depends on a combination of complex physical and chemical mechanisms, the most important being adsorption [13].

ISBN: 978-93-86171-95-5

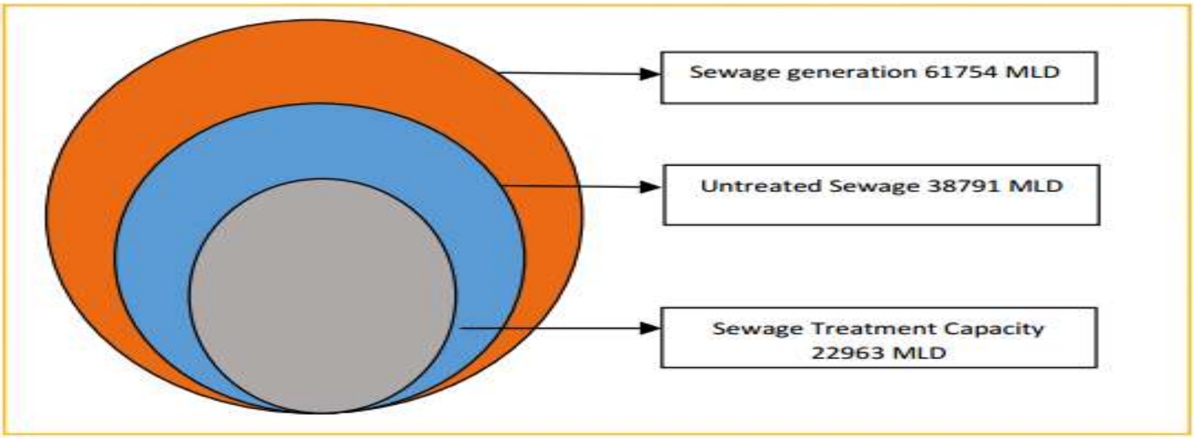

Fig 1.Status of sewage generation and Treatment [6].

Slow sand filters are commonly used in water treatment to remove contaminants by physical, chemical and biological mechanisms but they may not be effective in the removal of specific contaminants, 'emerging contaminants' (EC), or precursors to disinfection by-products (DBP), such as dissolved organic carbon (DOC) [14],[15],[16].Intermittent soil filers are being used to treat secondary effluent from waste water treatment and storm water runoff. These filters work on the same principle of slow sand filtration but differ in some operational features such as filter media grain size, filtration rate and operation mode [17],[18].Bio filtration encompasses all forms of water filtration that include a biologically mediated treatment component, and this includes a wide variety of applications, designs, media, filtration rates, and water treatment capabilities. This review focuses particularly upon intermittent slow sand filtration (SSF) or bio-sand filtration (BSF), a ―low technology water treatment process that has a long history of successful international application. The performance of BSF is controlled by an ecosystem of living organisms (biolayer or schmudzdecke) whose activities are affected by the raw water quality, and in particular, by the temperature. The quality of the treated water and the maintenance requirements for the system depend on selected variables like sand size, flow rate, and sand bed depth. In present research efforts have been made to develop a low cost and low maintenance model of sand intermittent filtration for the treatment of wastewater.

Table 1: Economics of different levels of treatments through conventional measures [8].

Particulars	**Primary treatment system**	**Primary + ultra-filtration system**	**Primary + ultra-filtration system + reverse osmosis**
Capital cost (Rs lakhs)	30.0	90.64	145
Annualized capital cost (@15% p.a. interest & depreciation	5.79	18.06	29.69
Operation and maintenance cost (lakhs/annum)	5.88	7.04	12.63
Annual burden (Annualized cost +O&M cost) Rs. Lakhs	11.85	27.1	42.5
Treatment cost Rs./kl (Without interest and depreciation)	34.08	52.40	73.22

II. MATERIAL AND METHOD

In the present investigation we applied an experimental method design to compare the effectiveness of the filter media such as sand and gravel and different mixtures of sand and gravel. It analysed the output of water base on the following parameters viz. pH, TDS, TSS, TS, DO, BOD, COD, Chloride, Total Hardness (TH), and Calcium Hardness (CaH). The samples were analysed and surveyed before and after the filtration which was done using sand intermittent filtration technology.

2.1 Design of experimental setup-The experimental setup was made in the 20 liters transparent Bisleri water bottle of 25cm diameter and 40cm height of each bottle. Four set up was made. The total height of the 1st, 2nd, 3rd and 4th experimental set up was respectively 80cm, 120cm, 120cm and 80cm. In each experimental setup further three sub setups were made. In the 1st sub setup the width of each bed is15cm, in the 2nd sub setup the width of each bed is 20cm and in the 3rd sub setup the width of each bed is 30cm. A one litre mug was placed at the base of the tank to collect the treated water for analysis of physico-chemical parameters.

2.2 Filter-media –Sand of medium sized particles and gravel was collected from building material suppliers and then the filter media was washed with tap water and distill water and then oven dried at 105^{0}C. After drying the sand was sieved to separate the large particle was used for making filtration beds. In the present study filtration bed used contained 100% sand while in other setups different mixtures of sand and gravel in different ratios i.e. 1:1, 1:2, 2:1 were used in the preparation of Sand Intermittent Filtration bed in the experimental setup.

2.3 Sample collection and analysis– The sample was collected on monthly basis from an industrial area located in Uttarakhand. The collected sample was not completely industrial effluent and was not completely sewage but it was a composite of both of these. The sample was collected in the morning hours between 7AM to 10 AM. The analysis was performed according to [19], [20], [21].

III. RESULTS AND DISCUSSION

The sand intermittent filtration system is a highly biologically active unit, therefore, the filter has to be operated for several days to develop a biological film (schmutzdecke) on the grain of the filter until the, purifying bacteria become well established and plays an important part in the treatment process [22] and [23]. The biological conditions governing the effectiveness of the slow sand filter are (i) the degree of scum formation and (ii) the microbiological maturity of the sand bed [24], [25]. The results of various physico-chemical parameters are given in table-2 while percentage removal was given in table-3.

The pH of waste water was found 8.13±0.21. [26] Were also observed similar results of TS in waste water. Minimum removal in pH was found 1.23% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the depth of 15 cm while maximum removal was found 6.15% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm. Our findings are more or less similar to [27], [13] and [28]. Slight variation from [27] findings was due to filtration media and width of filtration bed.

The TS of waste water was found 1296.67 mg/l ±15.28. Khanna et al 2014 were also observed similar results of TS in waste water. Minimum removal in TS was found 40.98% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the depth of 15 cm while maximum removal was found 42.39% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm. The TDS of waste water was found 989.00 mg/l ±9.64. Minimum removal in TDS was found 40.18% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the depth of 15 cm while maximum removal was found 44.02% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm. Our findings were more or less similar to [28] and [29].

The TSS of waste water was found 307.67 mg/l±8.74. Minimum removal in TSS was found 43.01% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the depth of 15 cm and 20 cm while maximum removal was found 46.26% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm. Our findings were more or less similar to [28]. Solids reduced after sand intermittent filtration because mixture of soil and sand works as a sieve. These results are in accordance with the findings of [27] and [11] Also due to retention time of sewage into Sand intermittent filter reduces total solids, total dissolved solids and total suspended solids.Approximately 50% reduction in TS, TSS and TDS found in the filtered effluent may be due to the retention of the solid particles in the filtration bed which can be the real cause of significant depletion of these parameters [31].

Table 2.Showing physico-chemical properties of waste water samples.

Parameters	**Values**
pH	8.13±0.21
Total Solids (TS) , mg/l	1296.67±15.28
Total Dissolved Solids (TDS), mg/l	989.00±9.64
Total Suspended Solids (TSS), mg/l	307.67±8.74
Turbidity (NTU)	112.33±2.52
Chloride (mg/l)	240.67±4.04
Dissolved Oxygen (DO), mg/l	0.50±0.10
Biochemical Oxygen Demand (BOD), mg/l	194.00±6.56
Chemical Oxygen Demand (COD), mg/l	323.33±8.62
Total Hardness (mg/l)	318.33±2.08
Calcium Hardness (mg/l)	116.67±5.13

The Turbidity of waste water was found 112.33 NTU±2.52. Minimum removal in Turbidity was found 42.73% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the

ISBN: 978-93-86171-95-5

depth of 15 cm while maximum removal was found 59.65% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm. Turbidity reduction may be due to reduction in the amount of suspended solids and dissolved solids. [32] Was found that turbidity was removed by 90% using slow sand filters. [33] Reported that 92% of turbidity was removed when slow sand filter was used for wastewater treatment. Variation in our findings, from [32], [11], [12] and [33] may be due to variation of sand granules and soil particles size as well as the depth of the bed. Turbidity removal was found more or less similar to [13].

The chloride of waste water was found 240.67 mg/l ±4.04. Minimum removal in chloride was found 12.47% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the depth of 15 cm while maximum removal was found 23.41% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm. A more or less similar trend of chloride reduction was also observed by [34].

The dissolved oxygen (DO) of waste water was found 0.50 mg/l ±0.10. Low values of dissolved oxygen concentration are associated with heavy contamination by organic matter [20]. Minimum gain in dissolved oxygen (DO) was found 20.00% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the depth of 15 cm while maximum gain was found 94.00% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm. The increase in the values of dissolved oxygen of waste after treatment may be due to the reduced amount of organic pollution load and the retention of bacterial population (organic pollutants and microbial population) in the filtration bed and simultaneously mixing of atmospheric oxygen during the process of treatment A more or less similar findings were observed by [11].

Parameters	Sand and Gravel (Ratio-1:1)			Sand and Gravel (Ratio-1:2)			Sand and Gravel (Ratio-2:1)			Sand (100%)		
	15 cm	20 cm	30 cm	15 cm	20 cm	30 cm	15 cm	20 cm	30 cm	15 cm	20 cm	30 cm
pH	-1.23	-2.46	-3.69	-2.46	-2.46	-3.69	-3.69	-4.92	-6.15	-2.46	-2.46	-4.92
TS	-40.98	-41.11	-41.31	-41.11	-41.29	-41.44	-41.52	-41.88	-42.39	-41.45	-41.67	-42.26
TDS	-40.18	-40.65	-41.32	-40.68	-41.15	-41.73	-41.35	-41.76	-44.02	-41.09	-41.56	-43.55
TSS	-43.01	-43.01	-45.40	-43.45	-43.77	-45.50	-43.88	-45.18	-46.26	-43.55	-43.99	-45.50
Turbidity	-42.73	-44.21	-46.59	-44.21	-44.81	-47.77	-48.66	-50.44	-59.65	-47.18	-48.07	-58.16
Chloride	-12.47	-13.16	-15.1	-13.16	-13.99	-16.35	-16.07	-17.87	-23.41	-15.65	-17.04	-22.44
DO	+20.00	+26.00	+40.00	+26.00	+46.00	+66.00	+54.00	+66.00	+94.00	+32.00	+40.00	+74.00
BOD	-7.22	-9.11	-11.17	-8.59	-11.17	-15.12	-14.60	-19.42	-32.99	-13.23	-18.04	-31.96
COD	-16.39	-18.97	-20.82	-17.22	-18.04	-18.87	-21.55	-23.71	-34.02	-20.62	-22.47	-31.96
Total Hardness	-40.21	-41.15	-43.04	-40.94	-42.72	-44.4	-46.28	-47.54	-51.41	-45.44	-46.91	-50.15
Calcium Hardness	-26.69	-30.57	-34.86	-30.30	-33.72	-37.15	-37.43	-42.00	-52.28	-38.01	-44.57	-49.71

Table 3.Showing percentage reduction (%) in physico-chemical properties of waste water after the treatment.

(-) = Showing Removal in the parameter

(+) = Showing Gain in the parameter

ISBN: 978-93-86171-95-5

The biochemical oxygen demand (BOD) of waste water was found 194.00 mg/l ±6.56. Bhutiani et al 2017 were also observed similar results of TS in waste water. Minimum removal in biochemical oxygen demand (BOD) was found 7.22% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the depth of 15 cm while maximum removal was found 32.99% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm. From the findings it was concluded that depth of filtration bed played an important role in purification of wastewater. [11] and [23] reported more than 65% reduction in BOD, when effluent was allowed to filter from 3.5 feet depth of sand filtration containing sand only of 0.3mm and then later 0.6mm in size and [11] reported 72.5% removal in BOD when effluent was allowed to filter from 2 feet depth of sand filtration containing a mixture of sand and soil in the ratio of 3:1. The variation from our findings may be due to variation in the media of filtration as in our case we use sand and gravel and also in the variation of bed width. Maximum percentage of BOD reduction may be due to lowering of temperature, which minimizes the multiplication of microbial (bacterial) population by generating unfavourable temperature resulted lowered uptake of oxygen and due to their retention in the bed [11]. More or less similar reduction potential was also observed by [30].

The chemical oxygen demand (COD) of waste water was found 323.33 mg/l ±8.62. Minimum removal in chemical oxygen demand (COD) was found 16.39% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the depth of 15 cm while maximum removal was found 34.02% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm. [11], [35] and [31] reported 78.96%, 76-82%, and 79% respectively but in our study maximum COD reduction was found 34.02% may be due difference in filter media and filter bed width Because [31] used sand and Soil in 3:1 with wood ash and charcoal ash. Our findings were more or less similar to [36]

The total hardness (TH) of waste water was found 318.33 mg/l ±2.08. Minimum removal in total hardness (TH) was found 40.21% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the depth of 15 cm while maximum removal was found 51.41% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm. Our findings were in accordance with and more or less similar to [28]. The calcium hardness (CaH) of waste water was found 116.67 mg/l ±5.13. Minimum removal in calcium hardness (CaH) was found 26.69% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 1:1 and the depth of 15 cm while maximum removal was found 52.28% after the treatment with Sand intermittent filtration in the mixture of sand and gravel having ratio 2:1 and the depth of 30 cm.

IV. CONCLUSION

The sand intermittent filtration technology is cost effective and provides an alternative economic way for the speedy treatment of waste water. But it requires further investigation regarding optimization of sand size and gravel types, composition of and characteristics of schmutzdecke (biolayer) layer and mathematical modeling to accelerate effective filtration capacity.Hence, this is a cost effective, without chemical operation and environmental friendly technology for waste water treatment.Combinations of biological and physico-chemical mechanisms are responsible for water treatment in sand intermittent filtration technology.In the present study generally sand and gravel beds have shown better performance than only sand bed for waste water treatment. Mixture of Sand and gravel bed at ratio 2:1 has yielded better results in general than all other used ratio.In all the experimental setups maximum percentage reduction was observed at 30 cm width of filtration bed.

REFERENCES

[1]. IWMI. International Water Management Institute annual report 2003-2004.

[2]. C. Rajeswaramma, Kapil Gupta. Hydraulic design of a constructed wetland for an urban area. J. Wat. Works. Asso. (2002), 149-152.

[3]. K. Kadirvelu, M. Kavipriya, C. Karthika, M. Radhika, N. Vennilamani, S. Pattabhi, “Utilization of various agricultural wastes for activated carbon preparation and application for the removal of dyes and metal ions from aqueous solutions”, Bioresour. Technol., vol. 87, 2003, 129-132.

[4]. Central Pollution Control Board. CPCB bulletin vol-1, July (2016).

[5]. CPCB. Parivesh Sewage Pollution – News Letter. Central Pollution Control Board, Ministry of Environment and Forests, Govt. of India, PariveshBhawan, East Arjun Nagar, Delhi 110 032 http://cpcbenvis.nic.in/newsletter/sewagepollution/contentsewagepoll-0205.htm (2005a).

[6]. Kumar RM. Financing of wastewater Treatment Projects. Infrastructure Development Finance Corporation and Confederation of Indian Industries. Water Summit, Hyderabad, 4–5 December 2003.

[7]. CPCB. Advance methods for treatment of textile industry effluents, Resource Recycling Series: RERES/&/2007. Central Pollution Control Board, India (2007b).

[8]. R Kaur, SP Wani, AK Singh and K Lal. Wastewater production, treatment and use in India. National Report presented at the 2 nd regional workshop on Safe Use of Wastewater in Agriculture, (2012).

[9]. L. Cl. Campos, M.F.J Su. Graham, N.J.D; Smith, S.R. Biomass development in slow sand filters. Wat. Res. 36, (2002), 4543-4551.

[10]. R.Rao, R.C. Ravinder Reddy, K.G. Rama Rao, P.S. Kelkar. Assessment of slow sand filtration system for rural water supply schemes-A case study. Indian J. Environ. Health. 45(1), (2003), 59-64.

[11]. G. Prasad, Rajeev Rajput, A.K.Chopra. Sand Intermittent Filtration Technology for safer Domestic Sewage Treatment .J. Appl. Sci. Environ. Mgt.10 (1) (2006),73 – 77.

[12]. G. Prasad, Rajeev Rajput, A.K. Chopra.Alternative economic technology for treatment of distillery effluent to prevent surface and ground water pollution. J. Appl. Sci. Environ. Manage.September, 2007, 11(3) 35 – 39.

[13]. BibhabasuMohanty, M. BeranGosai, K. Keval Patel, K. DhrvitTanna, G. VimalSorathiya. Design and Construction of a Modified Rapid Sand Filter for Treatment of Raw Water. Journal for Research, 3(3), (2017), 9-13.

[14]. D. Gang, T.E. Clevenger, S.K. Banerji. Relationship of chlorine decay and THMs formation to NOM size. Journal of hazardous materials, 96(1), (2003), 1–12.

[15]. Y.H. Chuang, G.S. Wang, and H. Tung. Chlorine residuals and haloacetic acid reduction in rapid sand filtration. Chemosphere, 85(7), (2011), 1146–53.

[16]. EPA. Drinking Water Report 2015, Johnstown Castle, Wexford, Ireland.

[17]. LfU. BodenfilterzurRegenwasserbehandlungimMisch- und Trennsystem(Soil Filters for Storm water Treatment in Combined and Separate Sewer Systems). Report of the LandesanstaltfürUmweltschutzt Baden-Württemberg, Karlsruhe, (2002).

[18]. K. Langenbach, P. Kuschk, H. Horn, M. Kästner. Slow sand filtration of secondary effluent for wastewater reuse. Environmental Science and Technology 43, (2009), 5896–5901.

[19]. APHA, AWWA, WPCF. Standard methods for examination of water and waste water, 20th Eds. American Public Health Association; 1015, Fifteen Street, New Washington, 15: (1998), 1-1134.

[20]. R.K. Trivedy, P.K. Goel. Chemical and Biological methods for water pollution studies. Environment Publication, Post box no. 60, Karad, (1986).

[21]. D.R. Khanna, R. Bhutiani. Laboratory manual of water and Waste water Analysis. Daya Publishing House New Delhi -110002, (2008).

[22]. Ellis, KoV., "Slow Sand Filtration," CRC Critical Review in Environmental Control, IS (4) (1985), 315-354.

[23]. K. V. Ellis. Slow Sand Filtration as a Technique for the Tertiary Treatment of Municipal Sewage," J. Wat. Res., 21(4), (1987), 403-410

[24]. W.D. Bellamy. D.W. Hendricks, G.S. Logsdon. "Slow Sand Filtration Influences of Selected Process Variables," J. AWWA,77(12), (1985), 62-66.

[25]. W.D. Bellamy, Silvennan, G.P. Hendricks, D.W., and Logsdon, G.S. "Removing Giardia Cysts with Slow Sand Filtration," J. AWWA, 77(2), (1985), 52-60.

[26]. R. Bhutiani, Hari Pratap, Faheem Ahamad, ParitoshKumar ,PankajDuttKaushik. Efficiency Assessment of Effluent Treatment Plant (ETP) Treating an Automobile Industry Effluent (Sidcul) Haridwar. Environment Conservation Journal 18 (1&2), 2017, 95-102.

[27]. A.Kumar, V. Singhal, B.D. Joshi, J.P.N Rai. Lysimetric approach for ground water pollution control from pulp and paper mill effluent using different soil textures. Ind. J. Sci. Ind. Res. 63, (2004), 429-438.

[28]. L., BhausahebPangarkar, B., SarojParjane and M.G. Sane. Design and Economical Performance of Gray Water Treatment Plant in Rural Region. World Academy of Science, Engineering and Technology 37, (2010), 896-900.

[29]. Khanna, D.R., Bhutiani R. Tyagi Varun and Ahamad Faheem. Impact of Sugar Mill Effluent on Physico-chemical Properties of Malin River at Najibabad, Bijnore. Indian. J. Sci. Res.Spl. Ed & NSESIR, (2014), 5-10.

[30]. A.E. Adeniran and J. O. Akanmu. The Efficiency of Slow Sand Filters in the Treatment of Secondary Effluent from a Water Hyacinth Domestic Sewage Plant. Nse Technical Transactions, 47, (2), April – June 2013.

[31]. L. E. Attah, M. Eyob. Modified Sand-Soil Filtration Bed as Alternative Economic Technology for Treatment of Distillery Effluent. Journal of Science, Engineering and Technology 1(2), (2012), 29-33.

[32]. P. Ojeda.Treatment of turbid surface water for small community supplies. Dissertation Abstracts International. 51(3), (1990), 1471-B.

[33]. G.E. El-Taweel, G.H. Ali. Evaluation of roughing and slow sand filters for water treatment. Water Air Soil Pollu. 120(1-2), (2000), 21-28.

[34]. B. SarojParjane, G. Mukund. Sane Performance of grey water treatment plant by economical way for Indian rural development.International Journal of Chem. Tech Research CODEN (USA): IJCRGG 3(4), (2011), 1808-1815.

[35]. J.C.L. Van Buuren, H. Willers, L. Luyten, M. Van Manen. The pathogen removal from UASB – effluent by intermittent slow sand filtration. In: Anaerobic treatment a grown-up technology, conference papers. Aquatec.,86, (1986). 707-709.

[36]. S. Mohan Venkata, K. Krishna Prasad, N. Chandrasekhar Rao, Y. VijayaBhaskar, V. LalitBabu, D. Rajgopal P.N. Sharma. Biological treatment of low-biodegradable composite chemical waste water using upflow anaerobic sludge blanket (UASB) reactor: Process Monitoring. Journal of scientific and industrial research.65, (2005), 771-777.