International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-3, Issue-11, November 2015

Study of Performance Evaluations of Decentralized Wastewater Treatment Systems to treat domestic wastewater: A review

V. S. Ghorpade, Dr. P.G. Sonawane

Abstract— **Today, Domestic wastewater treatment is the most important and complex issue in India. With increase in population, wastewater generation is boosted. The available treatment units are not satisfying the demand of treatment. So the untreated domestic wastewater is causing pollution of the surface water sources and land in which it was discharged. Hence to satisfy these conditions Decentralized Wastewater Treatment systems can be choose as most affordable and appropriate systems. Decentralized Wastewater Treatment The effluents with high levels of BOD, COD, TKN, TSS and TDS values are having great pollution potential. Hence the quality of such effluent can be analyzed by their physico-chemical and biological analysis. Monitoring of the water quality parameters of the effluent would allow having a precise idea on performance evaluation of Decentralized Wastewater Treatment and if necessary, appropriate measures may be undertaken to prevent adverse impact on environment. The results obtained through performance evaluation study are very much useful in identification and rectification of operational and maintenance problems and plan an appropriate strategies to enhance its effectiveness. Hence this paper reviewed the various studies on performance evaluations and removal mechanisms of Decentralized Wastewater Treatment plants and model which are having different types of combinations of processes developed for treating domestic wastewater.**

***Index Terms*— Decentralized Wastewater Treatment System, Performance Evaluation, physico-chemical and biological analysis.**

I. INTRODUCTION

Usually out of 70-80 % of total water supplied for domestic use gets generated as wastewater [2]. Normally, the domestic wastewater is expected to collect through sewerage network and treat the same at centralized sewage treatment plant. But in India domestic wastewater collection and treatment facilities are currently limited to hardly 40 % of geographical area [CPCB, 2004].The remaining wastewater was handled by the systems like conventional septic tank. But there are some cases in which it was found that septic tank is lacking in treating the wastewater which will meet the permissible limits to disposal and laid the contamination of soil as well as ground water [EPA]. Hence Advanced Decentralized Wastewater Treatment is rising as a better option in order to satisfy the demand of domestic wastewater treatment with more affordable and appropriate manner. The Decentralized Wastewater Treatment system is established in various countries including India in order to treat the wastewater rising in domestic area.

Along with installation the performance monitoring is also important. Performance evaluation has the benefit of assessing the performance of the wastewater treatment plant after commissioning the plant based on the removal efficiency of major parameters such as BOD, COD, TSS, TDS, Phosphate and TKN. Suitable remedial measures can be adopted to improve the performance of treatment plant. Hence the study should be carry out on evaluating efficiency of the treatment plant by studying water samples, which were collected at different stages of treatment units[7].The goal of meeting the disposal standards are best achieved where performance based management of onsite systems has been implemented to protect the quality of the receiving watershed [EPA]. Hence parameters like BOD, COD, TSS, TDS, Phosphate and TKN has to be studied because they are having great pollution potential.

As per the type of the treatment adopted and use of treated water the parameters for evaluation differs. Hence it is necessary to review similar practices which will clear the idea about parameters selection for particular process and from the observations drawn from particular performance evaluation study; their removal mechanism can be understood.

II. VARIOUS COMBINATIONS OF TREATMENT UNITS ADOPTED IN DECENTRALIZED SYSTEM

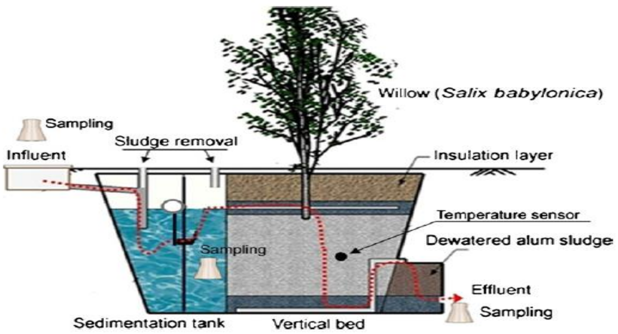
Raman et al. (2014) studied performance of the lab scale model of a compacted aerobic attached growth fix-film unit for treatment of small volume domestic wastewater. The result shows that at optimum hydraulic retention time (HRT) of 2 hrs. approximately 78% Chemical Oxygen Demand (COD), 88% Biological Oxygen Demand (BOD5), 32% Total Dissolved Solids (TDS), 72% Total Suspended Solids (TSS), 9% Chlorides, 75% ammonia nitrogen (NH3-N), 40% phosphate (PO4-P), 93% most probable number (MPN) and 95% total viable count (TVC) reduction was achieved in the Bio-cache system.[8] This study also indicates that the Bio-caches system offer the lower wastage biomass concentration and facilitate its greater management.

Azizi et al. (2013) conducted study to evaluate three biological processes (i.e. conventional activated sludge process, moving-bed biofilm reactor, and packed-bed biofilm reactor) in order to select the most appropriate treatment of wastewater from residential complexes. The performance of the systems showed that COD and BOD concentrations of treated effluent were below 100 and 30 mg/L at above 6, 3, and 2 h HRT in CASP, MBBR, and PBBR, respectively. Out of which PBBR found more effective, with Hydraulic retention time of 2 h for the laboratory scale model which results the overall reduction of 87% COD, 92% BOD5, 82%

V. S. Ghorpade, Civil-Environmental Engineering, Walchand College of Engineering, Sangli, India.
Dr. P.G. Sonawane, Civil-Environmental Engineering, Walchand College of Engineering, Sangli, India.

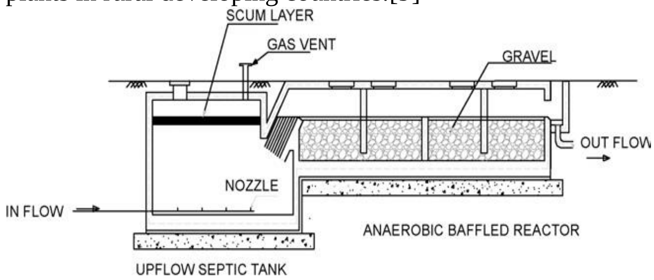
TSS, 79% NH3-N, 43% PO4-P, 95% MPN, and 97% TVC.[1] The results obtained from the study suggest that the conventional activated sludge has low degree of flexibility and treatment efficiency; however, the attached growth technologies are remarkably superior in pollutant elimination even at low hydraulic retention time from residential wastewater.

Wu et al. (2011) developed an integrated household constructed wetland (IHCW) system planted with willow (Salix babylonica) to treat household domestic wastewater in rural villages in northern China. The system consists of a two stage sedimentation tank and a vertical-flow, constructed wetland bed. Study of performance evaluations (which was carried out for 1 year) results the high overall removal efficiencies for BOD5, TSS, NH4-N, and TP were achieved for 96.0%, 97.0%, 88.4% and 87.8%, respectively. This study includes the use of dewatered alum sludge as a substrate in the treatment system to remove phosphorus because it has the potential to enhance P removal due to its high content of amorphous aluminum. Further, author focused on minimizing problems aroused due to seasonal variation. The 0.4 m insulating biomass layer maintained bed temperature above 6 ◦C in strong winter of -8◦C. There was negligible decrease observed in average removal efficiency for BOD5, TSS and NH4-N during winter (1.3%, 1.1% and 5.4%, respectively); while an increase of 0.6% was achieved for TP removal in winter period. Wallace et al., (2001) also concluded through his study that insulting sawdust layer is most probably responsible for the minimal change between winter treatment performance and the rest of the year. [12]



Schematic diagram of the integrated household constructed wetland system (the doted red line shows the water flow path). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

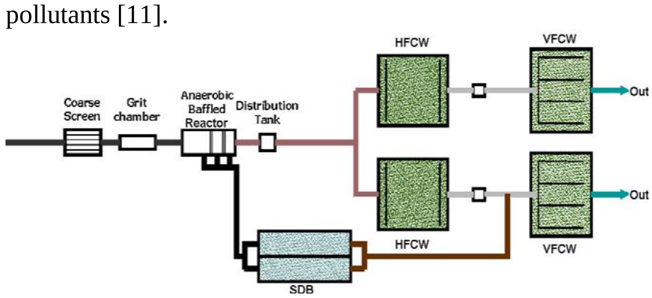
Sabry (2010) conducted a study on modified septic tank, named Up-flow Septic Tank/Baffled Reactor (USBR) which was constructed and tested in a small village in Egypt. One year of continuous operation and monitoring, this system results removal efficiencies of COD, BOD, and TSS were 84%, 81%, and 89%, respectively. The results showed that the system is slightly influenced by the drop in the temperature. Decreasing in BOD and COD removal by factor of 9% was observed, when temperature decreases from the average of 35 ◦C in summer time (for the first 127 days) to the average of 22 ◦C in winter time (between day 252 and day 280). The results of the sewage flow variations during one year of operation were compared with Goodrich Formula to see the applicability of this equation in rural developing countries. A small difference was found between the results from the Goodrich Formula and the flow variation in rural Egyptian. Hence the Up-flow Septic Tank/Baffled Reactor system could become a promising alternative to the conventional treatment plants in rural developing countries.[9]



Cross-sectional view in the modified septic tank system (USBR)

Feng H. (2008) developed carrier anaerobic baffled reactor (CABR) to treat sewage at 28 °C. The TCOD removal efficiency varied from 79% at 48 h HRT to 69% at an HRT of 18 h, implying that it declined with decreasing HRT to some extent. The average total SS removal efficiency was 81.92%, resulting in an effluent with 14.35 mg SS/ l. The effluent SS were influenced by decreasing HRT, which was determined by liquid up flow velocity, varying from an effluent with 11.8 mg SS/l at an HRT of 48 h to 14 mg SS/l at 18 h HRT.[3]

Singh S. et al. (2008) developed a model for decentralized wastewater treatment plant with Anaerobic Baffled Reactor (ABR) and hybrid Constructed Wetland to treats high-strength wastewater from households. The performance of the DEWATS was monitored from July 2006 to August 2007 for the parameters - TSS, BOD5, COD, NH4–N, TP and FC. The average removal efficiencies of the DEWAT model are 96% TSS, 90% BOD5, 90% COD, 70% NH4–N, 26% TP and 98% FC. Hence the author concluded that there is high potential of using ABR as primary treatment. ABR is very effective in the removal of organic parameters and could achieve TSS removal up to 91%, BOD up to 78% and COD up to 77%. The performance of the VFCWs planted with Phragmites karka and Canna latifolia, was not so encouraging because the shallower depth of 55 cm was used. The depth of the VFCW should be a minimum of 70 cm to achieve better performance in the removal of nutrients as well as organic pollutants [11].



Plan of the wastewater treatment plant

Yang et al. (2007) conducted a comparative study of the efficiency of contaminant removal among five emergent plant species in a small-scale Win Guangzhou, China. He demonstrated that there was a significant difference in the removal rate of TN and TP, but no significant difference in the removal of organic matter between vegetated and non-vegetated wetlands. The average removal efficiencies for TN and NH4-N in the vegetated wetlands were 75% and 72%, respectively, while those of the unplanted wetlands were more than 10% lower. Removal of TP was considerably higher in both, averaging over 90% for the vegetated wetlands and approximately 80% for the control wetland. He also reported that Pennisetum purpureum had the highest nutrient removal rates during the period from May to June, and Canna indica showed the highest removal rate during the month of August. The removal rate of Phragmites communis was the highest during the month of December. This finding implied that the removal efficiency of contaminants varied with season and patterns of plant growth, and the most vigorous growth period of the plants corresponded to high contaminant removal rates. Influence of temperature is an important parameter when the pollutant treatment effectiveness of a CW is evaluated. In general, the efficiency of treatment in a CW decreases at low temperature primarily because of reduced biotic activity.[13]

Korkusuz et al. (2005) study states that the increases in the influent concentrations can also be attributed to shock loads to the sewer system. As a result of the start of the new semester (September–October 2002) at Middle East Technical University, academicians and the students came back to their homes and dormitories. They used detergents in large quantities for cleaning purposes, produced more sanitary wastewater as compared to the summer season. This in turn resulted in steep increases in the TSS and TP; as well as increases in NH4-N and TN concentration values. Moreover, COD influent concentrations showed parallel changes to the changes of suspended solids and phosphorus concentrations, since COD values were also affected by the increase of the amount of organic pollutants and carbons of detergents. [5] Generally, the influent concentrations of almost all of the water quality parameters monitored in winter are higher than that of the parameters monitored in summer.

Halabi (2005) studied two types of decentralized wastewater treatment plants as practical cases implemented in Gaza strip. Both systems have included septic tanks, baffled septic tanks and anaerobic filter tanks. He found both the systems have failed to comply with international and local standards of treated wastewater reuse in irrigation. Improper designs of both systems had negatively affected the treatment efficiency. The design of both systems did not consider the flow quantity, failed to consider HRT, mass of used filters, type of irrigated soil and the capacity of irrigated crops to tolerate such water. Further he found decrease in removal efficiencies in winter. To overcome this problem he suggests the use of a solar system to raise the temperature of the wastewater to maintain high removal efficiency in winter as well as summer. [4]

Kyambadde et al. (2004) compared the wastewater treatment efficiencies of CWs planted with two local plant species, Cyperus papyrus and Miscanthidiumviolaceum, dominant in the Nakivubowetland in Kampala, Uganda. The authors reported removal efficiencies in CWs planted with C. papyrus of 75.43% NH4-N, 72.47% TN, and 83.23% TP, while that of CWs planted with M. violaceum of 64.59% NH4-N, 69.40% TN, and 48.39% TP. Both vegetated wetlands showed much higher removal efficiencies than those in the unplanted control bed (28%, 25.6%, and 8% for NH4-N, TN, and total reactive P, respectively). He showed that plant uptake and storage was the major factor responsible for N and P removal in CWs planted with C. papyrus(where the plant contributed to 69.5% for N and 88.8% for P of the total N and P removal). On the other hand, for the CW planted with M. violaceum, the plants only accounted for 15.8% N and 30.7% P of the total N and P removal. Their results also indicated greater removal of both TP and NH4-N in CWs dominated by C. papyrus (83% and 75%, respectively) than in those with M. violaceum (49% and 62%, respectively). [6] The authors also observed significantly higher dissolved oxygen concentrations in CWs planted with C. papyrus than in those with M. violaceum.

III. CONCLUSION

These reviews shows that the performance evaluation is done mostly by considering the parameters like COD, BOD, TSS, TKN and TP. The flow given to the system is inversely proportional to the removal efficiency. Hence more HRT will give more efficiency. While evaluating developed system, some common problems like design without consideration of flow quantity, temperature variation, bed depth and pattern of plant growth (in case of constructed wetlands) can be observed which will affect the effluent quality. So due to this the advancement is must in order to nullify the problem. At various places these problems were handled with various techniques. Hence we can conclude that doing advancement in system the results of performance evaluation will act as guide which will facilitates to meet the desired effluent quality with more effective manner.

REFERENCES

[1] S. Azizi, A. Valipour, and T. Sithebe, "Evaluation of Different Wastewater Treatment Processes and Development of a Modified Attached Growth Bioreactor as a Decentralized Approach for Small Communities," The Scientific World Journal, Vol 2013 (2013), Article ID 156870

[2] CPHEEO (2012), Manual on Sewerage and Sewage Treatment, Part A: Engineering Final Draft, Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, New Delhi

[3] H.J. Feng, L.F. Hu, Q. Mahmood, C.D. Qiu, C.R. Fang, and D.S Shen, , "Anaerobic domestic wastewater treatment with bamboo carrier anaerobic baffled reactor," International Biodeterioration & Biodegradation, Vol. 62 (2008), 232–238

[4] M.K. Halabi "Evaluation and Design Model of Decentralized Units for Wastewater Treatment," doctorate thesis, unpublished

[5] A. Korkusuz, B. G. Meryem, and G.N. Demirer, ― "Comparison of the treatment performances of blast furnace slag-based and gravel-based vertical flow wetlands operated identically for domestic wastewater treatment in Turkey" Ecological Engineering, vol. 24, (2005), 187–200

[6] J. Kyambadde, F. Kansiimea, L. Gumaeliusb and G. Dalhammarb, "A comparative study of Cyperus papyrus and Miscanthidium violaceum-based constructed wetlands for wastewater treatment in a tropical climate," Water Research, vol. 38, (2004), 475–485

[7] S. Patel, Rajor A., Jain B.P. and Patel P., "Performance Evaluation of Effluent Treatment Plant of Textile Wet Processing Industry: A Case Study of Narol Textile Cluster, Ahmedabad, Gujarat," International Journal of Engineering Science and Innovative Technology (IJESIT),Volume 2, Issue 4, July 2013

[8] V. K. Raman, A. Valipour, S. Taghvaei, G. Gholikandi, S. Jamshidi and N. Hamnabard, "An approach on attached growth process for domestic wastewater treatment", Environmental Engineering and Management Journal, 2014, Vol.13, No. 1, 145-152

[9] T. Sabry, "Evaluation of decentralized treatment of sewage employing Upflow Septic Tank/Baffled Reactor (USBR) in developing Countries", Journal of Hazardous Materials, 2010, vol. 174, 500–505

[10] S. Singh, R. Haberl, O. Moog, R.R. Shrestha, P. Shrestha and R. Shrestha , "Performance of an anaerobic baffled reactor and hybrid constructed wetland treating high-strength wastewater in Nepal—A model for DEWATS," Ecological Engineering, 2009, vol. 35, 654–660

[11] UN-HABITAT, 2008. Constructed Wetlands Manual, UN-HABITAT Water for Asian Cities Programme Nepal, Kathmandu, Nepal

[12]S. Wu, D. Austinb, L. Liua and R. Dongc, "Performance of integrated household constructed wetland for domestic wastewater treatment in rural areas," Ecological Engineering, 2011, vol. 37, 948–954

[13] Q., Yang, Z.H. Chen, J.G. Zhao and B.H. Gu,"Contaminant removal of domestic Wastewater by constructed wetlands: effects of plant species," Integr. Plant Biol, 2007, vol .49, Issue 4, 437-446