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Aerobic Brickbat Grit Sand (ABGS) Purifier is the Decentralize approach for wastewater treatment

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ABSTRACT

This study illustrated that the Aerobic Brickbat Grit Sand (ABGS) Purifier system is an ideal practice for decentralized wastewater treatment. Decentralized wastewater treatment is the only solution to reduce the environmental burden as well as to tackle the scarcity of water in developing and undeveloped countries. In the developing countries, treatment of domestic wastewater is not a primary objective of development because requirement of huge funds for collection of wastewater and to construct centralized treatment facilities as well as need of technical experts for managing the treatment plant. Providing simple, cost effective and eco-friendly wastewater treatment is a challenge in many parts of the world. Decentralized wastewater treatment is the solution to reduce the environmental burden as well as to tackle the scarcity of water in developing and undeveloped countries. In this situation Aerobic Brickbat Grit Sand (ABGS) purifier serves as an alternative option to treat the domestic wastewater in the decentralized way. The present study emphasizes on the approach of ABGS for decentralized wastewater treatment. Working model of ABGS purifier was setup for the treatment of grey water at Government College of Engineering, Aurangabad, M.S., India. The variations in physicochemical parameter of the influent and effluent show pH (7.2±0.1 to 7.6±0.1), BOD (189±33 to 11±1 mg/l), COD (354±47 to 26±5 mg/l), TSS (92±6 to 13±3 mg/l), TDS (393±51 to 430±43 mg/l), Total phosphorus(30±3 to 6±0.6 mg/l), Nitrate (5±1 to 0.5±0.1 mg/l), Ammonia(0.6±0.2 to 0.04±0.1 mg /l), Sulphate (43±1 to 14±3 mg/l), Chloride (86±10 to 78±7 mg/l), Oil and grease (5.1±0.3 to 1.9±0.5 mg/l). ABGS purifier is eco-friendly and cost effective domestic wastewater treatment system constructed with use of locally available material.

***Key words**: BOD, COD, Grey water, Turbidity, Total phosphorus, TSS*

Introduction

The wastewater treatment facilities broadly classified into two concepts centralized and decentralized wastewater treatment system. Centralized wastewater treatment system implemented and utilized to treat the wastewater in highly populated or urbanized areas. Centralized system deals with large volumes of wastewater for large communities. Massoud *et al.* (2009) reported that centralised wastewater collection and treatment systems are expensive to construct and operate, especially in areas with low population densities and dispersed households. Developing countries lack both the

([1]Lecturer, [2]Professor, [3]Associate Professor, [4]Professor) funding to construct centralised facilities and the technical expertise to manage and operate them. On the other hand decentralized treatment system appears as a logical solution to tackle sustainability problems of wastewater management systems, as it focuses on the on-site treatment of wastewater and on local recycling and reuse of resources contained in domestic wastewater (Capodaglio, 2017). According to the Environmental Protection Agency in the United States, decentralized wastewater systems may provide a cost-effective and long-term option for meeting public health and water quality goals, particularly in less densely populated areas. (USEPA, 1997). The capital investment for decentralized wastewater systems is generally less than for centralized systems in pri-urban areas, and they are also likely to be cheaper to construct and operate. By tackling wastewater problems close to source, the large capital investment of trunk sewers and pumping costs associated with centralized systems can be reduced, thus increasing the affordability of wastewater management systems (Parkinson and Tayler, 2003).

Septic tank is a commonly used on-site, simple decentralized system to treat wastewater, followed often by soil disposal. Anaerobic process occurring in septic tanks, which results in low conversion of organic components. Sludge accumulation at the bottom and accumulation of floating oil and fats in a surface scum layer, gradually reduces the net available volume, and hence wastes retention time. If septic tanks not managed properly can lead to overflow of wastewater into the surrounding localities, causing detrimental health impacts. Consequently, sludge and scum need to be removed periodically. Septic tank does not offer much in terms of resources and energy recovery. Although limited by poor efficiency, septic and Imhoff tanks (and many other similar design variations) are still vastly used in low income and remote areas, especially for isolated dwellings. In addition to these activated sludge-based plants, Membrane Biological Reactors, Anaerobic Digestion Systems several other process technologies are being preferentially developed for use in decentralized systems (Capodaglio 2017).

Shohreh Azizi *et al.* (2013) evaluate the potential future use of three biological processes in order to designate the most desired solution for on-site treatment of wastewater from residential complexes, that is, conventional activated sludge process (CASP), moving-bed biofilm reactor (MBBR), and packed-bed biofilm reactor (PBBR). He found that application of packed bed biofilm reactor (PBBR) could serve as an ideal process and holds a great promise for on-site residential wastewater treatment but it needs the detailed pilot scale and field studies.

Kujawa (2006) distinguished two situations of decentralised wastewater treatment system first system related to treatment of total domestic wastewater and second system is to treatment of separated wastewater streams. In source-separation based wastewater treatment concepts wastewater streams are separated according to their degree and type of pollution and reuse potential of resources. Different degrees of separation can be applied. Generally three types of wastewater streams are distinguished: black water, grey water and rain water. Grey water is a voluminous stream characterised by lower concentrations of pollutant in comparison with black water.

A recent advance in the technology along with favorable changes in attitudes towards wastewater reuse suggests that there is a potential for grey water reuse in the developing countries (Odesh, 2003). Large volumes of grey water are generated, accounting for 50–80% of domestic wastewater (Li *et al.*, 2006; Oron *et al.*, 2009; Yu *et al.*, 2013). In Australia, the study showed that water saving was in the range of 30–50% when grey water was used for toilet flushing and lawn irrigation (Jeppesen, 1996). Eric *et al.* (2013) conducted the study of current grey water practices globally, with a specific focus on household-level grey water practices in the Middle East and North Africa region, and highlighted the need for cost reduction strategies and epidemiological evidence on the use of household-level grey water and treated grey water. Since 1970's, numerous technologies are developed for treatment and recycling of grey water.

Ghaitidak and Yadav (2013) reviewed the grey water treatment systems, founded that Coagulation/flocculation systems were found weak in BOD removal but more efficient in pathogen removal. Constructed wetland is efficient compared to other system and feasible for treatment of a large quantity of grey water. Filtration is one of the feasible options but has further scope to study the role of different filtration media. MBRs are found efficient in removal of physicochemical contents and satisfy relevant reuse standards. However, they were not effective in removing microorganisms that were larger than the membrane pore size. Anaerobic followed by aerobic system may be a sustainable option for grey water treatment for reuse.

High COD: BOD ratio, and nitrogen and trace nutrients deficiency in grey water limits treatment efficiency of biological treatment processes for grey water (Jefferson *et al.*, 2001). For example, rotating biological contactor (RBC) (Friedler *et al.*, 2006) sequencing batch reactor"(Lamine *et al.*, 2007, Krishnan *et al.*, 2008). Performance of biological treatment can also be affected due to variation in flow and strength of the grey water (Pidou *et al.*, 2008). A photocatalytic treatment technology under artificial and solar illumination was used for the mineralization of simulated light grey water (Tsoumachidou, 2016). Limited data are available in the literature on specific pathogens in grey water (Winward *et al.*, 2008). If BOD and microorganism concentration is more in the grey water, biological treatment is necessary to reduce the contamination and its reusability. Disinfection is also essential to eliminate pathogens (Birks, 2007). Chowdhury (2015) investigated grey water reuse in the arid region for Bio-retention system. During the life cycle impact assessment of grey water recycling technologies, Maimon *et al.* (2010) observed low environmental impact of natural treatment system. Thus, main objective of study is to design and development of cost-effective and eco-friendly aerobic brickbat-grit sand (ABGS) wastewater purifier and investigate its efficiency for treatment of grey water.

Materials and Methods

Self-purification treatment process of river is utilized in the present study. The natural self-purification process is accelerated for removal of contaminants from grey water. AGBS purifier utilizes equalization, aeration, sedimentation, and filtration process. ABGS purifier operates on the principle of gravitational flow, thus avoid pumping and energy cost. The ABGS purifier has five stages in sequence viz. equalization tank, brickbat filter, bio-grit-sand filter, *canna Indica* flower bed, and aeration fountain. ABGS purifier operates under continues flow as per given sequence. The layout of ABGC purifier (5.60 m length, 0.9 m width and 1.2 m average depth) is as shown in Figure 1, which was designed to treat 9 cum/day of grey water. Chemical analysis was carried out as per the standard methods (APHA, 2005).

As shown in Figure 1, the first stage of ABGS purifier is an equalization tank. It is design for equalization of raw grey water properties as well as the settlement of the sludge. The second stage of the ABGS purifier is filled with a brickbat. Three partition walls are provided at closure frequency in the brickbat stage which forms zig-zag flow pattern for proper mixing of grey water. This stage is designed to replenish sudden fall of oxygen demand after organic outfall. It also helps to reduce the concentration of pollutant.

The third stage of ABGS purifier is filled with grit, sand, like the second stage of ABGS purifier, the third stage is designed with three partially opened partition wall which forms zig-zag flow. The first partition wall of the third stage is filled with grit at the bottom and sand at the top. The next two partition wall is filled with sand at the bottom and grit at the top. The designed surface flow, as well as subsurface flow in this part, imparts mechanical strain-

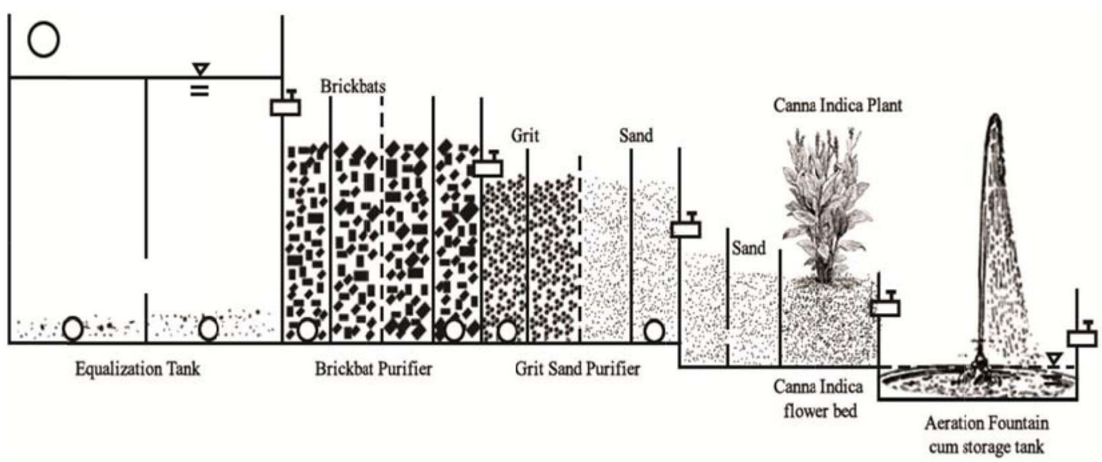

Fig. 1. Layout of Aerobic Brickbat Grit Sand (ABGS) Purifier

ing which helps to remove suspended solids. Moreover, sand and grit present at this stage allows small particle to get adsorbed on the surface of sand and grit particles due to molecular attraction between negatively charged particles and positively charged particles. This also helps bacterial growth in the voids of sand grains. The zoological biofilm forms on the surface of sand grains. The bacteria feed on organic impurities in water. They convert organic impurities into harmless compounds by complex biochemical action. Also, the third stage permits the electrolytic changes. Wherein, opposite electrical charges get neutralized and by doing so, new chemical substances forms. Moreover, backwashing arrangment at this stage helps to reduce organic matters in grey water. The fourth stage consists of two partition wall filled with charcoal layers and grey water flows up and down. The top layer ofthethe fourth unit has *Canna Indica* flower plants for beautification. Flow arrangement of the fourth stage, each down flow compartment consist of charcoal, which also helps in removal of certain organics such as unwanted taste, odor, andmicropollutants. The fifth stage of AGBS facilitates aeration using five nozzles. It elevates dissolved oxygen level in grey water which improves the odor.

Results and Discussion

Poilt model set up of ABGS purifier was constructed and operated for treatment of grey water from boy's hostel of Government College of Engineering, Aurangabad. Grey water from the hostel was allowed to flow through ABGS purifier under gravity without any pretreatment and considering 30 minutes of hydraulic retention time (HRT). The performance of the ABGS is evaluated by measuring removal of pH, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids(TDS), Total Phosphorus, Nitrate, Ammonia, Sulphate, Chloride, Oil and Grease, and Turbidity, for consecutive 49 days of summer season respectively.Results are expressed as an arithmetical mean.

Physico-chemical removal performance

Influent and Effluent of pH was found to be 7.1–7.6 showing the buffering capacity of ABGS purifier. Influent Oil and grease concentration in influent were 5.1±0.3 mg/l which was reduced to 1.9±0.4 mg/l. Influent TDS was found to be 393±51 mg/l, and effluent TDS was 429±42 mg/l it is slightly increased. Similarly, Chloride values change marginally from 86 ± 10 to 78 ± 7 mg /l. Sulphate at the influent was 43 ±1 which was 14 ± 1 mg/l at effluent observed with registering 67% removal. Over a period of 49 days operation of ABGS purifier, moreover, effluent was colorless and odorless

Suspended substances (SS) removal

Suspended substances play an important role in evaluating the performance of treatment and hence the degree of contaminant removal influent. Therefore, removal of TSS is one of the detrimental criteria in wastewater treatment. In this study filtration of TSS is done within the second stage where TSS caught into the rough textures and pores as well as into the voids of brick bates, Further SS matters removed by the filtration through grit and sand media. Moreover, more TSS matter removed in the fourth stage of charcoal media. Here, influent contents were 92± 6 mg/l, which reduced to 14±3 mg/l registering 85 % removal.

BOD and COD removal

BOD and COD express removal of organic load in wastewater. To reduce a load of pollution in the natural water bodies, an alternative effective, low-cost treatment method is needed. Therefore, in this study potential of using locally available eco-friendly materials for BOD and COD removal was investigated. Influent BOD was 189 ± 33 mg/l, and effluent levels reduced to 11 ± 1 mg /l. Similarly, COD at the influent of grey water was found to be 354± 47 mg/l and effluent COD level was 26 ± 5 mg/l. Most notable removals were 65-70% observed with a fired brickbats filter at stage second of the ABGS purifier system. The same is due to high organic matter adsorption capability of fired bricks bats. Further, stages of ABGS purifier consist of grit, sand and aeration fountain was attributing for BOD and COD removal 90-94% and 85-92 % respectively.

Nutrient removal

The nitrate removal treatment process is relatively expensive. Therefore, waste and natural indigenous materials were utilized for removal of nitrate and ammonium ions.(Shamim Ahsan *et al.*, 2001). Concentration of nitrate ions in the influent was 5±1mg/L. The NO_3 ion level of effluent was 0.5 ± 0.1 mg/L registering 90% removal.

Total Phosphorus concentrations in the influent were 30 ± 3, mg /l. Total Phosphorus levels reduced to 6 ± 0.7 mg/l registering 80% removal.

Ammonia concentration in the influent was 0.6 ± 02 mg/l and its level reduced to 0.05 ± 0.02 mg/l registering 91 % removal.

However, at the second stage of brickbat filter, 90-85%, 20-15%, 60-55% of NO_3, Total Phosphorus, Ammonia respectively was removed due to brick bats. Complex ingredient content of brick exchanges ions with contaminants leads of better adsorption of contaminants on the brick surface.

Efficiency chart of pilot model

Pilot scale model efficient in removal of various parameters as shown in Figure 4. BOD, COD, TSS, nitrate, ammonia removal rate was more than 85% whereas total phosphorus and chloride removal rate was more than 65%. This result shows the capability of ABGS purifier for the treatment of grey water.

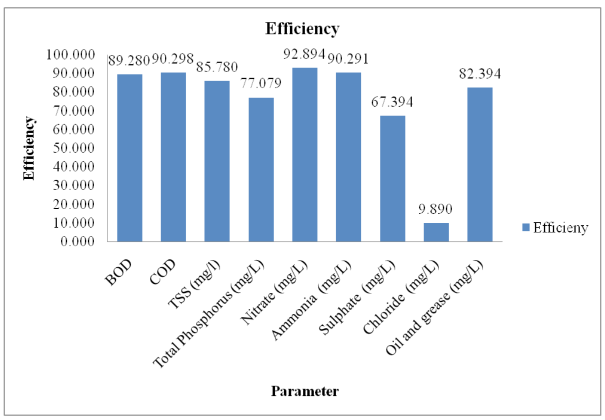

Fig. 2. Efficiency chart of pilot model

Treatment mechanism

Fired bricks are burned in a kiln which makes them durable, normally; bricks contain the silica, alumina, lime, iron oxide and magnesia ingredients. Similarly, grit and sand materials occur as silicate, aluminate and calcium substrates in different forms. Therefore, using these naturally available materials the possible basic fundamental mechanisms for treatment are: aeration, filtration, sedimentation, physical adsorption and ion exchange. Suspended substances were mostly removed by mechanical straining, filtration, and sedimentation, while the Nitrate, Total Phosphorus, and Ammonia were removed by ion exchange or by physical adsorption.

Efficient removal of BOD, COD have been attributed due to effective adsorption of organic matters in the large pores space area of fired bricks and charcoal. Aeration fountain accelerates the dissolved oxygen level as well as remove the odor. The horizontal and vertical flow pattern of the system properly mixes the grey water which results in better aeration during the treatment process.

However, because of the negligible concentration of magnesia in the bricks pH and TDS levels slightly increase up to ascertain extent. The construction cost for ABGS Purifier was 500 USD (on 2017), and projected annual maintenance cost is 60 USD for nine cum/day. Abdulrahim (2017) noted that the Grey water treatment system is not a maintenance-free system. It requires a regular maintenance particularly for the top layer of the sand filter due to the accumulation of grease, food particles, hair, lint and other impurities. In ABGS purifier backwashing of sand is done after 15-20 days that is why there was no need to remove the top layer of sand. In ABGS purifier, food particles, hair, lint link matters are removed in the first stage of equalization. Oil and Grease removed in the pores bricks and grit in second and third stage respectively. The efficiency of ABGS purifier system for removal of Biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), turbidity, oil and grease, Total Phosphorus, Ammonia, Nitrate, Chloride, and Sulphate, is satisfying the Indian standards for surface water discharge.

Conclusion

The present study focuses decentralized approach of ABGS purifier for the treatment of domestic wastewater. ABGS purifier pilot plant model for grey water treatment show high efficiency in removal of BOD (94%), COD(88%), TSS (80%), Total Phosphorus (90%), Nitrate (91%), Ammonia(67%), Sulphate (67%), Oil and grease(67%). Moreover effluent was colorless and odorless. Summing up, the unique feature of ABGS purifier are it is eco friendly, simple to construct, requires minimum land, and electrical power as well as costly mechanical equipment for the treatment is not required. ABGS purifier requires low retention time for the treatment of influent it provides green ambiance. It offers the onsite wastewater treatment facility to dwelling, Institutions, clusters of housing, rural localities and pre urban areas.

References

Abdulrahim M. Al-Ismaili,Mushtaque Ahmed, Ahmed Al-Busaidi, Seif Al-Adawi, Roman Tandlich, and Mohammed Al-Amri, 2017. Extended use of grey water for irrigating home gardens in an arid Environment. *Environ Sci Pollut Res.* 24: 13650–13658, doi: 10.1007/s11356-017-8963-z.

American Public Health Association (APHA) 2015. Standard Methods for the Examination of Water and Wastewater. American Water Works Association and Water Pollution Control Federation, Washington, DC.

Birks, R. and Hills, S. 2007. Characterization of indicator organisms and pathogens in domestic grey water for recycling. *Environ Monit Assess*. 129: 61–69, doi: 10.1007/s10661-006-9427-y.

Capodaglio, A.G. 2017. Integrated, Decentralized Wastewater Management for Resource Recovery in Rural and Peri-Urban Areas. *Resources*. 6: 22; doi:10.3390/resources6020022

Chowdhury, R.K. 2015. Grey water reuse through a bioretention system prototype in the arid region. *Water Sci. Technology.* 72 (12) : 2201-2211, doi: 10.2166/wst.2015.442.

Eriksson, E., Auffarth, K., Henze, M. and Ledin, A. 2002. Characteristics of grey wastewater. *Urban Water.* 4: 85–104, doi: 10.1016/S1462-0758(01)00064-4.

Eric C. Leas, Anne Dare and Wael K. Al-Delaimy 2013. Is Grey water the Key to Unlocking Water for Resource-Poor Areas of the Middle East, North Africa, and Other Arid Regions of the World?. *AMBIO*. 43: 707–717, doi: 10.1007/s13280-013-0462-y.

Friedler, E., Kovalio R. and Ben-Zvi, A. 2006. Comparative study of the microbial quality of grey water treated by three on-site treatment systems. *Environmental Technology*. 27 : 653–663, doi: 10.1080/09593332708618674.

Ghaitidak, D.M. and Yadav, K.D. 2013. Characteristics and treatment of grey water—A review. *Environmental Science and Pollution Research International.* 20: 2795–2809, doi: 10.1007/s11356-013-1533-0.

Hernández, L., Temmink, H., Zeeman, G. and Buisman, C.J.N. 2011. Characterization and anaerobic biodegradability of grey water. *Desalination*. 270 : 111-115. doi: 10.1016/j.desal.2010.11.029.

Jeppesen, B. 1996. Domestic grey water re-use: Australia's challenge for the future. *Desalination*. 106: 311–315, doi: 10.1016/S0011-9164(96)00124-5.

Jefferson, B., Burgess, J.E., Pichon, A., Harkness, J. and Judd S. 2001. Nutrient addition to enhancing biological treatment of Grey water. *Journal of Water Resource.* 35 (11) : 2702–2710, doi: 10.1016/S0043-1354(00)00553-4.

Krishnan, V., Ahmad, D. and Jeru, J.B. 2008. Influence of COD: N: P ratio on dark grey water treatment using a sequencing batch. *J Chem Technol Biotechnol*. 83: 756–762,doi: 10.1002/jctb.1842.

Kujawa-Roeleveld, K. and Grietje Zeeman, 2006. Anaerobic treatment in decentralised and source-separation-based sanitation concepts. *Reviews in Environmental Science and Bio/Technology.* 5 : 115–139. doi: 10.1007/s11157-005-5789-9

Lamine, M.L. and Bousselmi, A.G. 2007. Biological treatment of grey water using sequencing batch reactor. *Desalination.* 215: 127–132, doi: 10.1016/j.desal.2006.11.017.

Li, F., Wichmann, K. and Otterpohl, R. 2006. Review of the technological approaches for grey water treatment and reuses. *Science of the Total Environment*. 407: 3439–3449, doi:10.1016/j.scitotenv.2009.02.004.

Maimon, A., Tal, A., Friedler, E. and Gross, A. 2010. Safe on-site reuse of grey water for irrigation—A critical review of current guidelines. *Environmental Science and Technology*. 44: 3213–3220, doi: 10.1021/es902646g.

Massoud, M.A., Tarhini, A. and Nasr, J.A. 2009. Decentralized approaches to wastewater treatment and management: Applicability in developing countries. *J. Environ. Manag.* 90: 652–659. *doi*:10.1016/j.jenvman.2008.07.001.

Odeh, R.A. 2003. Grey water reuse: towards sustainable water management. *Desalination.* 156 : 181–192, doi: 10.1016/S0011-9164(03)00340-0.

Oron, G., Adel, M., Agmon, V., Friedler, E., Halperin, R., Leshem, E. and Weinberg, D. 2009. Grey water use in Israel and worldwide: standards and prospects. *Water Research.* 58: 92–101. doi:10.1016/j.watres.2014.03.032.

Parkinson, J. and Tayler, K. 2003. "Decentralized wastewater management in per urban areas in low-income countries. *Environment and Urbanization.* 15(1): 75-90.

Prathapar, S., Jamrah, A., Ahmed, M., Al Adawi, S., Al Sidari, S. and Al Harassi, A. 2005. Overcoming constraints in treated grey water reuse in Oman. *Desalination.* 186 : 177–186, doi: 10.1016/j.desal.2005.01.018.

Shamim Ahsan, Satoshi Kaneco, Kiyohisa Ohta, Takayuki Mizuno and Keiko Kani, 2001. Use of Some Natural And Waste Materials For Waste Water Treatment. *Wat. Res.* 35(15): 3738–3742, 2001,doi: 10.1016/S0043-1354(01)00047-1.

Shohreh Azizi, Alireza Valipour and Thami Sithebe, 2013. 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, Article ID 156870, pp.1-8,doi: 10.1155/2013/156870.

Tsoumachidou, S. 2016. Grey water as a sustainable water source: A photocatalytic treatment technology under artificial and solar illumination. *Journal of En-*

vironmental Management. pp. 1-10, doi: 10.1016/j.jenvman.2016.08.025.

US EPA 1997. Response to congress on use of decentralized wastewater treatment systems. EPA-832-R-97-001b, US EPA Office of Water, April 13.

Yu Z. L. T., Rahardianto, A., DeShazo, J. R., Stenstrom, M. K. and Cohen, Y. 2013. Critical review: regulatory incentives and impediments for onsite Grey water reuse in the United States. *Water Environ. Res.* 85 (7): 650–662, doi: 10.2175/106143013X13698672321580.

Winward, G.P., Avery, L.M., Frazer-Williams, R., Pidou, M., Jeffrey, P., Stephenson, T. and Jefferson, B. 2008. A study of the microbial quality of grey water and an evaluation of treatment technologies for reuse. *Ecological Engineering.* 32: 187–197,doi:10.1016/j.ecoleng.2007.11.001.