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Aerobic Brickbat Grit Sand (ABGS) Purifier is the Alternative Solution: Tackling the Problem of Rural Wastewater Treatment in India

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Abstract

Rural wastewater treatment is mostly ignored in developing and undeveloped countries. The most important barrier for addressing to this problem is cost of treatment and simplified technology. Aerobic Brickbat Grit Sand (ABGS) purifier consists of four stages. Wastewater flows gravitationally through partition walls in zigzag pattern with brick bats filter; Pebble sand filter and charcoal and grit filter which facilitate removal of contaminants from domestic wastewater. In the present study, experimental model for domestic wastewater treatment was setup in the Environmental Engineering laboratory at Government College of Engineering Aurangabad, Maharashtra. Physiochemical analysis was done in August and September of 2016 the percentage removal of contaminants results shows Biological Oxygen Demand (BOD) 92% - 87%, Chemical Oxygen Demand (COD) 93 - 89% , Total Suspended Solids(TSS) 80 - 78% and Turbidity 95 - 85%. The process is considered eco-friendly and easy to install technology for domestic wastewater treatment with use of locally available material. ABGS purifier is decentralized approach of domestic wastewater treatment. Hence ABGS as an alternative solution to tackle over the problem of rural wastewater treatment.

Article History

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Keywords

Aerobic Brickbat Grit Sand Biological Oxygen Demand,
Chemical Oxygen Demand,
pH,
Total Suspended Solids,
Turbidity.

Introduction

In 2015 not only most of the countries in world have adopted the agenda for sustainable development 2030 but also agree to take its 17 goals of the sustainable development. Even though 2.5 billion people from the world still, lack of access to developed sanitation facility.[28] Though world achieves sanitation target but the Sustainable development goal 3 will not satisfying it is just because of lack of wastewater treatment facility. A developing country such as India where the majority of population living in rural area. Open defecation is one of the major problems.

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For example the government of India introduced Central Rural Sanitation Programme (CRSP) in1986 by considering these views, CRSP program was improved in the year1999 and titled as 'Total Sanitation Campaign (TSC). Afterwards in 2003 the government reintroduced *Nirmal Gram Yojana* (Clean Village Campaign)[26] as a new programe.

The Indian government presented a flagship programme in the Swachh Bharat Mission (SBM) in 2014 the aim to made open defection free villages for that construction of 110 Million toilets up to 2019 targeted. The toilet construction data shows 11.80 Millions toilets between 2008 and 2009, 12.4 Million toilets from 2009 to 2010 , 12.2 Million toilets in (2010-2011), 8.8 Millions toilets from 2011 to 2012 total 4.55 Millions toilets in (2012-2013) 4.97 Millions toilets from 2013-2014, 5.85 Millions toilets were constructed in rural India in from 2014 to 2015.[27]

However, 8.5% of households who are residing in rural area have "underground" drainage system which is reflected as both, safest and modern system of the drainage report. The drainage arrangement in India for wastewater can be considered from the wastewater coming from households and its disposal following data shows that 36.7.% villages had pakka nail,19 % villages had kacchi nail and 44% villages had no drainage facilitates.[26]

Swachhta status report 2016 showed that out of the villages who has drainage arrangement the waste water coming from rural households were being directly disposed off to the nala in case of 24% of villages, directly release to the pond is 44.4% case of 15.8% villages and to the river in case of 6.8 % villages in the rural part of India.[27]

The census of India in 2011 had reported that 106.146 Million rural households were without a drainage arrangement. This situation is very alarming as far as environment and health concern. The treatment of drainage discharge is not just a matter of concerning to wastewater treatment but it is closely relating to economics and overall development of each nation addressing to domestic wastewater generated from individual household or from village. There are various physical, chemical and biological options for wastewater treatment such as Activated Sludge Process, Trickling Filter, Lagoon, Ozone Oxidation, Floatation, Sedimentation, Land Treatment and Wetland System. However, predominantly in developing countries, high construction cost and more importantly, high operation cost limits their application. For example Constructed Wetlands (CWs) have found to be in place for municipal wastewater treatment.[8,20] Several units of Natural and CW systems in North America and subsurface flow CWs in Europe are operational for wastewater treatment.[21] Most of the non-conventional systems such as Wetlands and land treatment have used.[10,11,17]

In 1993 natural soil was used to facilitate wastewater treatment in the multi-soil-layering (MSL) system.[25] In the countries like such as Japan and Thailand had successfully implemented the wastewater treatment project of domestic and restaurant wastewater and even polluted river water.[12] The system has not only depleted levels of inorganic contaminants such as nitrate, ammonium and phosphate but also organic contaminants like COD, BOD. This is also referred as a biphasic layered system which is used locally available materials such as iron particles, soil, jute or sawdust, charcoal, and zeolite or alternative materials etc.[3,12] In an anaerobic sheet layer of soil mixture block, nitrate is converted into nitrous oxide and nitrogen gas (denitrified) and ferric iron is depleted to the extra mobile ferrous iron, which goes out of anaerobic sheet layer of soil.[25] Although an adequate amount and perfect timing of aeration is important with the maintenance of an MSL system is not a complex system and the effective life span of such systems was predicated to be more than 10 years.[12] Since many year natural waste water systems is used on large scale which is substituted by the conventional system for the sanitation of small communities because of less electric requirement's and low maintenance costs.[6,13,24,5,16]

Constructed Soil Filter (CSF) known as Soil Biotechnology (SBT)is a particular type of unit system which not only works in formulating soil environment in which fundamental processes of nature *viz.,* respiration, mineral weathering but also brings photosynthesis together about the bioconversion.[15,19,10] There are several types of land treatment systems such as slow-rate irrigation system[14], overland flow system[21], rapid infiltration systems, sand filters[4], soil infiltration systems[6], and intermittent buried sand filters.[18] A process cost is not matching with processing demands with local operative skills and space constraint has lessen their uses.[4] The treatment of wastewater is well known to all but not at all utilized due to poor soil and the chocking of the same so large space requirement and vague water quality reaching the ground water. SBT is good and easy method of treatment but existence and development of bacteria, and adequate space for construction n and the problems of treatment of unit its filtering and cleaning affecting of its uses.

The main aim of present study is not only focusing the problems of rural wastewater treatment but also providing a system for the purification of domestic wastewater by easiest, economically and eco-friendly way.

Materials and Methods

The ABGS purifier consist of four stages in sequence on the principle of gravitational flow; equalization tank, brickbat purifier, pebble and sand purifier, and char coal and grit purifier. The AGBS purifier processes are; equalization, aeration, sedimentation, and filtration. A layout dimension of experimental model of ABGS purifier as shown in Figure 1. Details about media used in each unit of ABGS purifier given in Table 1.

The first unit of ABGS purifier is an equalization tank. It is helpful for equalizing of raw water properties. Moreover the second stage consist of Brickbat purifier it has three partition walls that provided at closure frequency which has forms zig-zag flow pattern for proper mixing and of the domestic wastewater. This unit replenishes depletion of oxygen demand after organic outfall and reduces the concentration of pollutants. The third unit of ABGS purifier fills with pebbles and sand. Similar to the second unit, it has three partition walls which have forms zig- zag flow.

Moreover, at this stage, pebbles and sand present and molecular attraction between negatively charged particles and positively charged particles, and allows small particle to get adsorbed on the surface of sand and grit particles.In the same way, it helps bacterial growth in the voids of sand grains, formation of zoological biofilm on the surface of sand grains. The bacteria are developed in the process and uses organic impurities in water for their feeding. They convert organic impurities into harmless compounds by a complex biochemical action, after that it reduces organic matter in the domestic wastewater. The fourth unit consists of three partition walls to provide up and down flow of the domestic wastewater with char coal media in first two compartment and further two compartment with a grit media.

Result and Discussion

Samples of a municipal wastewater have been collected daily and passed through the ABGS purifier. Its physiochemical analysis of BOD, COD, Turbidity

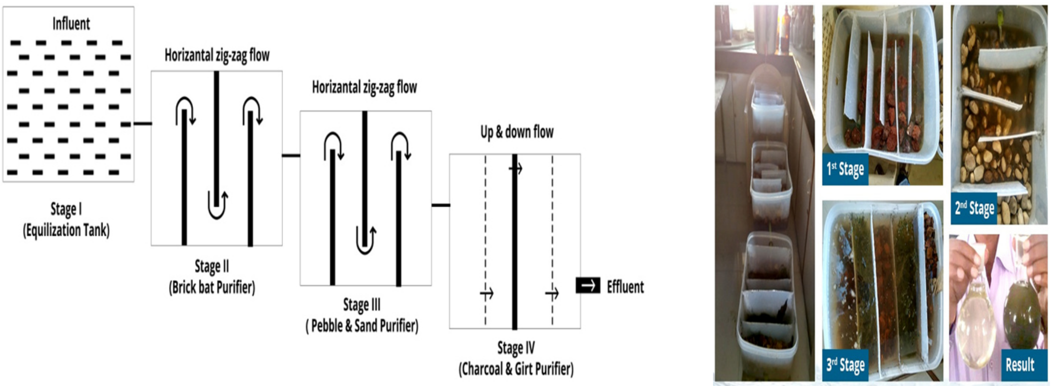


Fig. 1: Layout of ABGS purifier

TSS and pH is carried out as per standard methods of APHA, 2005[1]. Results tabulated in Table 2.

Removal of BOD and COD

Figure 2 show the BOD values of Influent (120–143 mg/L) and effluent (9-18 mg/L) with removal efficeiency of 92-87% while figure 3 represent the COD values of Influent (345-352mg/L) over Effluent (20-40 mg/L) with COD removal efficeiency of 93-89 % .

Removal of Total Suspended Solids (TSS)

Suspended substances play an important role in characterizing the treatability and hence the degree of contaminant removal in waste water. Therefore, removal of TSS is one of the detrimental criteria in domestic wastewater treatment. Fig.4 TSS concentrations in the raw sewage were 91 ± 6 mg/L, which was reduced to 13 ± 3 mg /L. This show 80 - 78% removal efficiency.

Removal of Turbidity

Figure 5 shows the turbidity levels in the influent (54-78 NTU) and effluent (03-13 NTU) with removal efficiency of 95 - 85%.

pH Level

Influent pH (7.7-6.9) and effluent pH (8.0-7.2) of all the samples were found to be close to neutral showing buffering capacity of ABGS as shown in Figure 6.

Performance Characteristics for Various Methods

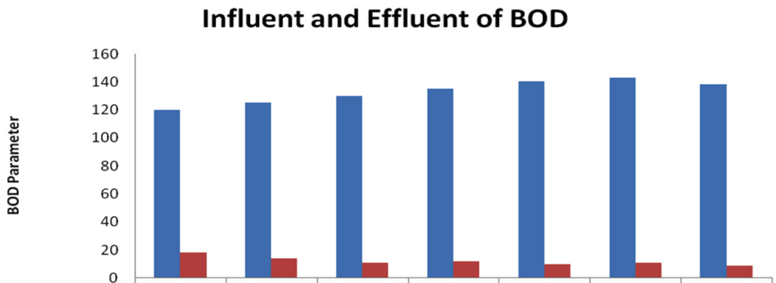
The values are given in the Table 3 compares a few selected mechanized and natural methods of treatment. Each treatment method has compared

Table 1: Details of the ABGS purifier

Beds	Medium	Size of Material (mm)	Bed Dimensions (m)	Bed Surface Area (m^2)	Flow Pattern
I[st]	Brick-Bates	80-100	0.60*0.45*0.45	0.27	Zig- Zag
II[nd]	Sand (Lower Media)	0.25-1.00	0.60*0.45*0.20	0.27	Zig- Zag
	Pebbles (Upper Media)	40-60	0.60*0.45*0.10		
III[rd]	Charcoal And	30-50	0.30*0.45*0.45	0.135	Up- down
	Grit	5-10	0.30*0.45*0.45	0.135	Up- down

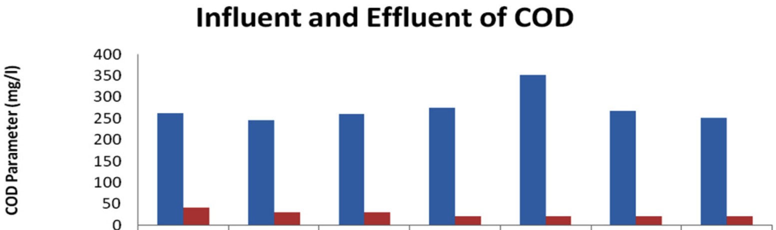
Table 2: Performance of an experimental model for the treatment of municipal wastewater

.Avg. Week	Municipal wastewater Parameters in 2016									
	BOD (mg/L)		COD (mg/L)		Turbidity (NTU)		TSS (mg/L)		pH	
	Influent (Avg.)	Effluent (Avg.)	Influent (Avg.)	Effluent (Avg.)	Influent (Avg.)	Effluent (Avg.)	Influent (Avg.)	Effluent (Avg.)	Influent (Avg.)	Effluent (Avg.)
2 Aug.2016	120	18	262	40	54	13	86	22	7.3	7.7
9 Aug. 2016	125	14	245	30	58	10	84	20	7.0	7.4
16 Aug.2016	130	11	260	30	67	08	92	27	6.9	7.6
23 Aug.2016	135	12	275	20	55	05	95	24	7.2	7.5
30 Aug.2016	140	10	352	20	70	06	87	18	7.0	7.9
6 Sept.2016	143	11	267	20	60	08	100	21	7.3	8.0
13 Sept.2016	138	09	252	20	65	04	97	18	7.3	7.6



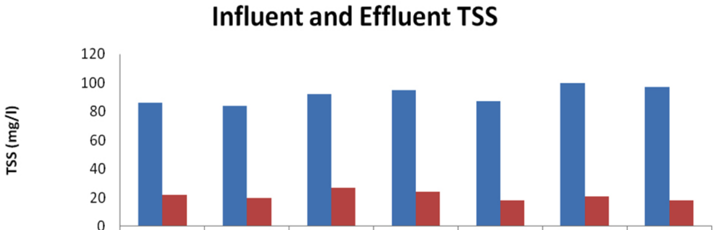
	2 Aug.2016	9 Aug. 2016	16 Aug.2016	23 Aug.2016	30 Aug.2016	6 Sept.2016	13 Sept.2016
Influent (Avg.)	120	125	130	135	140	143	138
Effluent (Avg.)	18	14	11	12	10	11	9

Fig. 2 : Variation of BOD Vs time in weeks



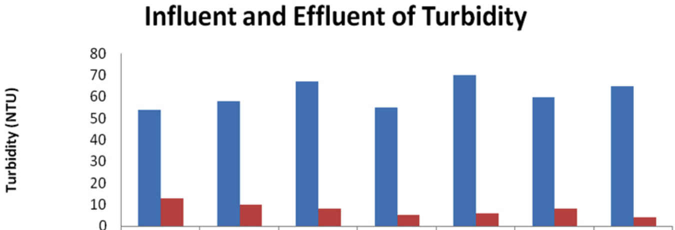
	2 Aug.2016	9 Aug. 2016	16 Aug.2016	23 Aug.2016	30 Aug.2016	6 Sept.2016	13 Sept.2016
Influent (Avg.)	262	245	260	275	352	267	252
Effluent (Avg.)	40	30	30	20	20	20	20

Fig. 3 : Variation of COD Vs time in weeks



	2 Aug.2016	9 Aug. 2016	16 Aug.2016	23 Aug.2016	30 Aug.2016	6 Sept.2016	13 Sept.2016
Influent (Avg.)	86	84	92	95	87	100	97
Effluent (Avg.)	22	20	27	24	18	21	18

Fig. 4: Variation of TSS Vs time in weeks



	2 Aug.2016	9 Aug. 2016	16 Aug.2016	23 Aug.2016	30 Aug.2016	6 Sept.2016	13 Sept.2016
Influent (Avg.)	54	58	67	55	70	60	65
Effluent (Avg.)	13	10	8	5	6	8	4

Fig. 5: Variation of Turbidity Vs time in weeks

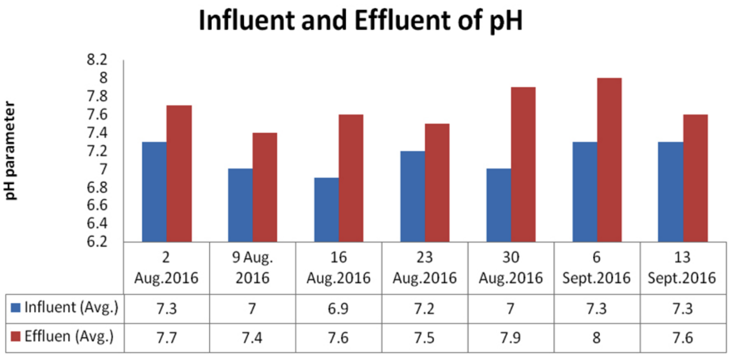


Fig. 6 : Variation of pH Vs time in weeks

Table 3: Typical performance characteristics for various methods[2]

Process	BOD Removal %	Land, sq m/ person	Operational Characteristics	Equipment requirement (Excluding screening and grit removal which are required in all cases)	Sludge Handling
Extended aeration	95-98	0.15 – 0.20	Simpler than activated sludge	Aerators, recycle pumps, sludge scrapers (for large settlers)	No Digestion, dry on sand beds or use mechanical dewatering devices
Conventiona l Activated sludge	85-92		Skilled operation required	Aerators, recycle pumps, scrapers, thickeners, digesters, dryers, gas equipments	First digest then dry on beds or use mechanical devices
Conventiona l Trickling filters	80-90	0.20 – 0.30	Skilled operation required	Trickling filter arms, recycle pumps, sludge scrapers, thickeners, gas equipment	First digest then dry on beds or use mechanical devices
Facultative aerated lagoon	75-85	0.30- 0.40	Simple	Aerators only	Manual desludging once in5-10 years
UASB's	75-85(a)	0.15- 0.20	Simpler than activated sludge	Nil (except gas collection and flaring; gas conversion to electricity is optional)	Directly dry on sand beds or use mechanical devices
Waste Stabilization Pond	75-85	1.0-2.8	Simplest	Nil	Manual desludging once in5-10 years
Land Treatment/ Irrigation	80-90	10-20	-	Sprinklers or drip irrigation(optional)	Nil
ABGS Purifier Annually	90-94%	0.05-0.03	skilled operation required. It works on gravitational flow	Simplest, No amt. of power required to operate 1HP pump for 15 min. daily for the aeration purpose)	Nil (Except small Directly dry on Beds

with a treatment by the ABGS Purifier .In the terms of various criteria or parameters in order to compare the ABGS purifier for the wastewater treatment.

A land requirements for the ABGS purifier is 0.05-0.03(sq.m/person) which is less as compared with the typical methods, in addition the used media for the ABGS purifiers is simple and locally available hence it proves that it is an economical method of the wastewater treatment.

Conclusion

ABGS purifier experimental model has been developed and applied to treat the domestic wastewater at Government college of Engineering Aurangabad campus. General objective of this study was to develop the decentralized domestic wastewater treatment system by using locally available material, no pretreatment requirement, less land requirement, minimum electrical power requirement and no mechanical parts. Results show that removal of BOD (120-143 to 9-18 mg/L), COD (345-352 to 20-40 mg/L), TSS (84-120 to 15-27mg/L), Turbidity (54-78 to 03-13 NTU) and pH (7.7-6.9 to 8.0-7.2) levels. Percentage wise contaminants removal are BOD (92% - 87%), COD (93 - 89%) and TSS (80 - 78%) and Turbidity (95 - 85%) . The efficiency of ABGS purifier for removal of BOD, COD, TSS, Turbidity and Physical properties are satisfied standards for discharging treated wastewater (Ministry of Enivironment, and Climate Change,India, 2017). It is recommended that the ABGS purifier used to treat the domestic wastewater in rural areas.

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