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Feasibility Study of Domestic Wastewater using Hybrid Process

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Abstract:
With the introduction of stringent effluent standards, it is the responsibility of wastewater treatment engineer to treat the wastewater to satisfy the requirement of receiving streams. The wastewater is conventionally treated either by Attached Growth System or by Suspended Growth System. Recently a new trend is developed to adopt the combination of Attached and Suspended Growth System of treatment. The combinations of treatment systems provide better results and as such the efforts will be made to study the efficiency of treatment. The combined activated & suspended growth system is advantageous for improvement of the efficiency. The present paper describes techniques for effective domestic waste management. Effort is made to treat the domestic waste by developing a technique such as Hybrid Process. Hybrid process is a technology which enhances the efficiency of domestic wastewater treatment. Hybrid process is a technique of using attached & suspended growth system by effectively using the advantages of both systems. The performance of various reactors best on attached & suspended growth system is discussed. Suitability of attached & suspended growth system is discussed thoroughly. The lab scale model is operated for different operating conditions at different detention time. To study the performance of the reactor a laboratory model is fabricated with steel having appropriate dimension. The model is provided with appropriate arrangements of inlet, outlet arrangements. Extensive study is carried to study the performance of reactor various parameter such as BOD, COD. Energy & cost consideration of combined attached & suspended growth system is discussed.

Keywords: Attached growth system, Suspended growth system, Removal efficiency, media, Diffused Aerators.

I. INTRODUCTION

Water Water is essential to all forms of life and makes up 50-97% of the weight of all plants and animals and about 70% of human body. Water is also a vital resource for agriculture, manufacturing, transportation and many other human activities. There are household uses such as showering, dishwashing, laundry and, of course, flushing the toilet. Despite its importance, water is the most poorly managed resource in the world. Wastewater is water that has been polluted due to anthropogenic activities. Wastewater is the byproduct of many uses of water. Types of wastewater include domestic, commercial, industrial and agricultural, categorized by their sources as well as type of contaminants and concentration. Untreated or inadequately treated wastewater discharged into a receiving stream brings with it biodegradable organic material that diverse communities of microbes decompose. These reduction/oxidation processes consume dissolved oxygen in streams and mineralize organically bound nutrients that become available to plants. The mineralized nutrients stimulate growth of algae at the base of the food web. Excessive microbial depletion of dissolved oxygen, or eutrophication, can impair the ability of streams, lakes or coastal waters to support aerobic forms of aquatic organisms. Untreated wastewater causes major damage to the environment and to human health. Almost always, therefore, wastewater should be treated in order to reduce the transmission of excreta-related diseases and to reduce water pollution and the consequent damage to aquatic biota. Only if there is a very large available dilution (>500) in the receiving watercourse can consideration be given to discharging untreated wastewater. Increasing affluent lifestyles, continuing industrial and commercial growth in many countries around the world in the past decade has been accompanied by rapid increases in both the municipal and industrial solid waste production. One of the many byproducts of civilization is waste. Waste arises from households, industrial factories, and other facilities to purge the unwanted wastes, sewage systems were created in populated areas. Sewage systems wash down the waste with water, disposing the resulting wastewater in the desired locations. The increase in population and the expansion of cities have led to a greater disposal of wastewater into the environment improper disposal of wastewater has led to outbreaks of disease arising from wastewater in many parts of the world. These outbreaks increased the need for wastewater management and treatment, driving the demand for wastewater treatment to higher levels. Wastewater is any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources. Wastewater also known as sewage originates from residential commercial and industrial area. Wastewater engineering is that branch of environmental engineering in which the basic principles of science and engineering are applied to solving the issues associated with the treatment and reuse of wastewater. The ultimate goal of wastewater engineering is the protection of public health in a manner commensurate with environmental, economic, social, and political concerns. When untreated wastewater accumulates and is allowed to go septic, the decomposition of the organic matter it contains will lead to nuisance conditions including the production of malodorous gases. In addition, untreated wastewater contains numerous pathogenic microorganisms that dwell in the human intestinal tract. Wastewater also contains nutrients, which can stimulate the growth of aquatic plants, and

may contain toxic compounds or compounds that potentially may be mutagenic or carcinogenic. For these reasons, the immediate and nuisance-free removal of wastewater from its sources of generation, followed by treatment, reuse, or dispersal into the environment is necessary to protect public health and the environment. Besides that, the purpose of wastewater treatment is to remove pollutants that can harm the aquatic environment if they are discharged into it. Because of the deleterious effects of low dissolved oxygen concentrations on aquatics life, wastewater treatment engineers historically focused on the removal of pollutant that would deplete the DO in receiving waters. Wastewater treatment methods can be classified as primary, secondary, and tertiary treatment. In primary treatment, physical barriers remove larger solids from the wastewater. Remaining particulates are then allowed to settle. Secondary treatment consists of a combination of biological processes that promote biodegradation by micro-organisms. Tertiary treatment processes are used to further purify the wastewater of pathogens, contaminants, and remaining nutrients such as nitrogen and phosphorus compounds. Domestic wastewater is defined as wastewater from household water use, while industrial wastewater is from industrial practices only. Treatment and discharge systems can sharply differ between countries. Also, treatment and discharge systems can differ for rural and urban users, and for urban high income and urban low-income users. Sewers may be open or closed. In urban areas in developing countries and some developed countries, sewer systems may consist of networks of open canals, gutters, and ditches, which are referred to as open sewers. In most developed countries and in high-income urban areas in other countries, sewers are usually closed and underground. The most common wastewater treatment methods in developed countries are centralized aerobic wastewater treatment plants and lagoons for both domestic and industrial wastewater. To avoid high discharge fees or to meet regulatory standards, many large industrial facilities pre-treat their wastewater before releasing it into the sewage system. Domestic wastewater may also be treated in on-site septic systems. These are advanced systems that may treat wastewater from one or several households. Water is one of the most valuable natural resources in the world. Unfortunately, it is being rapidly contaminated and urgent measures need to be taken for avoid its damage. In many countries, wastewater is released directly to lakes and rivers without treatment, and environmentally and economically feasible methods for wastewater treatment, are therefore, urgently needed. A large number of technologies have been developed to achieve pollutant removal from wastewater. Centralized wastewater treatment methods can be classified as primary, secondary, and tertiary treatment. In primary treatment, physical barriers remove larger solids from the wastewater. Remaining particulates are then allowed to settle. Secondary treatment consists of a combination of biological processes that promote biodegradation by micro-organisms. Tertiary treatment processes are used to further purify the wastewater of pathogens, contaminants, and remaining nutrients such as nitrogen and phosphorus compounds. The biological wastewater reactors are classified into attached growth and suspended growth. Attached growth technologies work on the principle that organic matter is removed from wastewater by microorganisms. These microorganisms are primarily aerobic, meaning they must have oxygen to live. They grow on the filter media (materials such as gravel, sand, peat, or specially woven fabric or plastic, essentially recycling the dissolved organic material into a film that develops on the media. Suspended growth treatment systems, such as biological treatment of water, involve the use of naturally occurring microorganisms in the surface water to improve water quality. Under optimum conditions, the organisms break down material in the water and improve the water quality. Suspended growth aerobic treatment is a process used to provide secondary and (in some cases) tertiary treatment of effluent. After primary treatment via liquid-solid separation, dissolved and some suspended organic matter is still present in effluent. If this organic matter is not removed before the effluent is dispersed, microorganisms in the receiving environment will begin to process it. As they consume the organic matter, they also consume oxygen or create an oxygen demand. Incorporating biofilm within the activated sludge process is one of the most commonly adopted configurations of the hybrid (CSAG) reactors. The combination of the two types of growth in one system (CSAG) has been found to be advantageous for improvement of the efficiency and/or capacity of existing treatment plants. During the attached growth process, microorganisms grow on a surface. The influent from the settlement tank is sprinkled over a suitable rocky substrate. Oxygen is required to establish an aerobic bacterial population. Newer designs often use electrically driven machinery for this. Older designs and those designed to be independent of electricity use gravity feed and natural air currents. Over time a layer of aerobic bacteria grows on the substrate. As the water flows over this the micro-organisms eat the contaminants in the waste water, converting them to water, carbon dioxide and other oxides. The suspended growth process is also known as activated sludge system. This system has two parts, an aeration tank and a settling tank.

The aeration tank has a "sludge", which is best described as a mixed microbial culture. This contains mostly bacteria, as well as protozoa, fungi, algae, etc. This sludge is constantly mixed and aerated either by compressed air bubblers located along the bottom, or by mechanical aerators on the surface. The wastewater to be treated enters the tank and mixes with the culture, which uses the organic compounds for growth--producing more microorganisms--and for respiration, which results mostly in the formation of carbon dioxide and water. The combined activated & suspended growth system (Hybrid process) is advantageous for improvement of the efficiency. The present paper describes techniques for effective domestic waste management. Effort is made to treat the domestic waste by developing a technique such as hybrid process.

The Hybrid reactor consists of three compartments with an array of attached growth with multi-media, maintained under diffused aeration to support attached biomass with suspended biomass recycle to promote suspended growth in the reactor. Hybrid process is a technology which adopts combination of both attached and suspended growth system to enhance the efficiency of domestic wastewater treatment by effectively using the advantages of both systems. The performance of various reactors best on attached & suspended growth system will be discussed. The study is carried out to study the behavior of combined treatment and to study the performance of the various packing media used in it. Suitability of attached & suspended growth system is discussed thoroughly. The lab scale model is operated for different operating conditions at different detention time. To study the performance of the reactor a laboratory model is fabricated with steel having appropriate dimension. The model is provided with appropriate arrangements of inlet, outlet arrangements. Extensive study will be carried to study the performance of reactor various parameter such as BOD, pH, TS, TDS, TSS. Energy & cost consideration of combined attached & suspended growth system is discussed.

II. REVIEW OF RELATED LITERATURE

Water is essential for all known life forms; still, water pollution and the destruction of ecosystems continue to increase. Water contamination is now a major problem in the global context as a consequence of industrialization, globalization, population growth, urbanization and warfare combined with increased wealth and more extravagant lifestyles. The spark in the demand for wastewater treatment led to new innovations in the wastewater treatment field, creating new treatment technologies and system processes. The names of publishers, who had done work in these areas, are as follows Karamany et al. (2001) Studied Aeration is used for transferring oxygen to wastewater in order to enhance the biological treatment process. A laboratory model simulating both suspended growth biological reactor and attached growth biological reactor was build in order to investigate the performance of the combined reactor. The present paper investigates the rate of oxygen transfer for four different configurations, three of them were tested using tab water and the fourth set of experiment was made using primary treated wastewater. First configuration investigated the oxygen transfer rate while the rotating disks operate alone. The second configuration investigated the oxygen transfer rate while the diffused air are in operation alone, and the third configuration investigated the oxygen transfer rate while both of the rotating disks and the diffused air are in operation together. The forth configuration investigated the oxygen transfer rate while both of the rotating disks and the diffused air are in operation together, but using primary treated wastewater sample instead of the tab water that had been used for the first three sets of experiments. Within the combined reactor the study showed better oxygen transfer rate can be get from the rotating biological contactor fill and draw rather than that of the diffused air system. Lee et al. (2001) Studied an attached growth bioreactor was designed to minimize the effect of suspended microorganisms on membrane fouling in submerged membrane bioreactor. Comparison of mixed liquor from attached and suspended growth systems was made to elucidate major factors giving rise to different filtration characteristics. Unexpectedly, the rate of membrane fouling of the in both processes are studied for the justification of the operational feasibility of each process. This study has proved that the BOD removal efficiencies of each process are equal and the nitrogen removal percentages are 43 % and 37% in attached growth process and suspended growth process respectively. Sludge production is 27 % less in attached growth process and thereby sludge handling is easy and aesthetically good. The land utilization and operational and maintenance cost have been estimated to identify the economical feasibility of each process. Monayeri et al.,(2006) studied the Combined suspended / attached growth (CSAG) systems have been emerging recently to increase the efficiency of the existing systems. It takes its importance from high biomass concentrations that can be achieved within the system. The present study investigates the enhancement (if any) of conventional activated sludge (AS) process performance using attached media submerged in the aeration tank. These two models worked parallel with the same influent wastewater and the same experimental conditions to investigate the effect of the added media volume in the aeration tank, the hydraulic retention time (HRT), and the sludge retention time (SRT), on the removing BOD5, and COD. Ratios of submerged media volume to reactor volume ranges from 10 % to 60% have been tested. It was found that 30 % was the optimum ratio of media submerged in the reactor. Rehman et al. (2012) [4] aimed towards designing and construction of efficient plastic media-trickling filter (TF) for the treatment of domestic wastewater. A shower rose was used as wastewater distribution system supported on the top of stone media bed. A net distance between the bottom of shower rose and top of filter bed surface was 9 inches. The flow of water was controlled by electric dimmer connected to the water pump. It was run under different treatment times (12, 24, 36 and 48 hrs) at 5-15ºC. After 48 hrs HRT, treated wastewater was then passed through SF. Parameters like COD, BOD5, TSS, turbidity, NO3, NO2, SO4, PO4 and pathogenic indicator microbes were monitored after treatment of 12, 24, 36 and 48 hrs. The efficiency of the TF was improved with increase of time from 12 to 48 hrs. Maximum efficiency of TF was observed after 48 hrs treatment viz. 93.45, 93, 86.25, 57.8, 63.15, 25, 32.43, 99.95 and 86.3% reduction from the zero time value for BOD5, COD, TSS, PO4, SO4, NO3, NO2, turbidity and fecal coliforms respectively. Finally 48 hrs treated sample was passed through sand filter (SF) for further final polishing and approximately, 95.72, 95, 100, 73.5, 65.8, 58.3, 37.83, 100 and 91.5% reduction in BOD5, COD, TSS, PO4, SO4, NO3, NO2, turbidity and fecal coliforms was observed. This study showed that plastic media-trickling filter along with sand filter is a promising technology for wastewater treatment and can be scaled up for small communities in the developing countries. Yeon et al.,(2011) Studied was expected more efficient removal rate and could be built more economical than existing plant and could be built more economical. In this case, as media packing ratio increased, the removal of nitrogen increased. From this result, increasing of biomass due to increasing of packing ratio could improve removal efficiency. The removals of phosphorus were 32.6%, 29.4%, 28.9%, respectively. In this case, as media packing ratio increased, the removal of phosphorus decreased. Because wasting of microorganisms by control SRT is more effective than media packing for phosphorus removal. Daigger et al. (2011) studied The modem trickling filter typically includes the following major components: (1) rotary distributors with speed control; (2) modular plastic media (typically cross-flow media unless the bioreactor is treating high-strength wastewater, which warrants the use of vertical-flow media); (3) a mechanical aeration system (that consists of air distribution piping and low-pressure fans); (4) influent/recirculation pump station; and (5) covers that aid in the uniform distribution of air and foul air containment (for odor control). Covers may be equipped with sprinklers that can spray in-plant wash water to cool the medias during emergency shutdown periods. Trickling filter mechanics are poorly understood. Consequently, there is a general lack of mechanistic mathematical models and design approaches, and the design and operation of trickling filter and trickling filter/suspended growth (TF/SG) processes is empirical. Some empirical trickling filter design criteria are described in this paper. Benefits inherent to the trickling filter process (when compared with activated sludge processes) include operational simplicity, resistance to toxic and shock loads, and low energy requirements. However, trickling filters are susceptible to nuisance conditions that are primarily caused by macro fauna. Process mechanical components dedicated to minimizing the accumulation of macro fauna such as filter flies, worms, and snail (shells) are now standard. Unfortunately, information on the selection and design of these process components is fragmented and has been poorly documented. The trickling filter/solids contact process is the most common TF/SG process. Kim et al. (2011) Studied aeration process can be easily applied on the existing activated sludge system and is highly reliable against the loading changes. It can be operated in a relatively simple way as well. Since the moving bed biofilm reactor method processes pollutants by attaching and securing the microorganism on the media, the process efficiency can be

higher compared to the suspended growth biological treatment process, and can reduce the return of sludge. The system being conducted in a laboratory scale has been operated in HRT 8 hrs except for the final clarifier and showed the removal efficiency of 97.7%, 73.1% and 9.4% in organic matters, TN & TP, respectively with operating range of 4 hrs cycle on system SRT 10days. After adding media, the removal efficiency of phosphorus showed a similar level compared to that before the addition, but the removal efficiency of nitrogen was improved by 7-10%.

III. MATERIALS AND METHOD

Experimental Set-Up*:*

The model is based on the principle of combined attached and suspended growth system. The model is fabricated with GI sheet consists of three reactors placed in series, in which two reactors is based on the principle of attached growth and one is on principle of suspended growth. The diffused aerators will be provided in the suspended growth system. As the wastewater comes in contact with media microorganism grows on surface of attached media i.e.in first reactor, in contact with liquid allowing digestion of organic matter & after the treatment from the attached growth system the partially treated wastewater will be transferred to the suspended growth reactor i.e. in second reactor and after the treatment of suspended growth system the wastewater is transferred to the 3rd reactor i.e. attached growth system & allow to remove the remaining impurities. This system will provides facilities for the combination of attached & suspended growth system & as such provides better option for oxygen. Inlet and outlet arrangements are provided at appropriate locations.

The Combined suspended & attached growth (CSAG) systems have been emerging recently to increase the efficiency of the existing systems. It takes its importance from high biomass concentrations that can be achieved within the system. The present study will be investigates the enhancement of combined attached & suspended growth system process performance using attached media submerged in the aeration tank. The model will be working at variable detention time & media. The wastewater from the inlet chamber flows in sequence i.e. from first reactor to the last reactor, passing through the attached and suspended system and enters the collecting chamber and is collected from the outlet .the wastewater from the inlet chamber enters the first reactor through the v-notch channel. The first reactor is packed with Elaeocarpus ganitrus. V-notch channel is provided so as to provide uniform distribution throughout the reactor. The wastewater thus passed uniformly through the first reactor and gets partially treated and enters the second reactor. The wastewater partially treated in the first reactor moved to the second reactor in down flow regime. Thus the wastewater thus rises uniformly at the same time it gets treated. The wastewater from the second reactor enters the third reactor in a uniform manner. The wastewater thus passes uniformly through the third reactor and gets treated and enters the collecting chamber by the upflow movement. Thus the wastewater passes through all the three reactors in upflow and downflow regime and gets collected in the collecting chamber after reaching the outlet level the treatment effluent is collected in the outlet tank.

IV. EXPECTED RESULT

It is expected that the combined attached & suspended growth system is better option for wastewater treatment. Hence the study will required to be undertaken to analyze the overall performance of CSAG under various time variation & on different media. The method use for wastewater treatment should be economical, simple in operation and easy to maintain. It is expected that materials such as Elaeocarpus ganitrus and cut pieces of PVC pipes may prove to be more efficient in improving the effluent quality in terms of its BOD and suspended solid content.

It is expected that the experimental model will significantly assist in the removal of BOD, TS, TDS, and TSS and will improve the pH quality of effluent. It is expected that this system will be quite efficient in BOD removal more than 70% and also expected that the other wastewater parameters will be obtained within range. Hybrid process is a recent development in the wastewater treatment technology which involves media and diffused aerators. It can conclude from the study that the hybrid process may be considered as efficient treatment process for domestic wastewater treatment. The recent development in the media types such as Elaeocarpus ganitrus and cut pieces of PVC pipes media has expanded new areas for study. Also the above media may enhance the performance of the treatment system. Hence, this technology is environment friendly and cost effective.

V. CONCLUSION

Hybrid Process i.e combined attached and suspended growth system has a potential in biological wastewater treatment. This technology is also a recent development which involves use of artificial media other than the conventional media as opposed to sand used in the conventional filters. It can also be concluded from the study that the Artificial Media filter may be considered as efficient pre-treatment process for wastewater treatment. The recent developments in the media types such as porous aero on media and plastic media have expanded new areas for study. Also, the above media may enhance the performance of the treatment system. Hence, this technology is environment friendly and cost effective.

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