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Performance Analysis and Life Cycle Cost Analysis of Activated Sludge Process (ASP): A Review

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Abstract: *Over a period of last few decades with the increase in technology the volume of waste water generated has also increased. Within this period the waste water ministerial regulation have led to a constant ascend in the purification performance of waste water treatment plants. The problem occurring these days is the less numbers of treatment plants and their improper functioning to treat the waste water. To overcome these problems a sagacious technological solutions have to be found. In this study, performance analysis (such as Bio-chemical oxygen demand (BOD), Chemical oxygen demand (COD) parameter etc.) of the activated sludge process of waste water treatment and life cycle cost of Activated Sludge Process (ASP) also analysis. In this review the information is provided in order to study the effectiveness of activated sludge process at laboratory scale basis and in terms of cost also.*

Keywords: *Activated Sludge Process (ASP), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Life Cycle Cost (LCC).*

I. Introduction

Wastewater contaminates with suspended solids, nutrients, heavy metals, pathogens, priority pollutants include dissolved inorganics, refractory organics and oxygen consuming organic matter. Suspended solids can lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharged in the aquatic environment.

When attempting to trace the development of the theory of activated sludge process over the past 25 years, one encounters an array of papers bewildering in their number and diversity of points of view. Only a thorough study will allow recognition and assessment of original ideas contributed in this year.

Activated sludge is a sludge particle reduced in wastewater by the growth of organisms in aeration tanks. The term ‘activated’ comes from the fact that the particles teem with bacteria, fungi, and protozoa and is different from primary sludge in the sense that the sludge particles contain many living organisms that can feed on the incoming wastewater.

The activated Sludge (AS) process was expanded as an intermittent to biological filters, and is particularly beneficial for large populations where land is at a premium. The Activated Sludge Process is biological treatment process which is a complex mix of microbiology and biochemistry importing many different sort of bugs.

Described simply, screened wastewater is mixed with varying amounts of recycled liquid containing a high proportion of organisms taken from a secondary clarifying tank, and it becomes a product called mixed liquor. This mixture is stirred and injected with large quantities of air, to provide oxygen and keep solids in suspension. After a period of time, mixed liquor flows to a clarifier where it is allowed to settle. A portion of the bacteria is removed as it settles, and the partially cleaned water flows on for further treatment. The resulting settled solids, the activated sludge, are returned to the first tank to begin the process again.

Today a number of variations of the basic process have been developed. This issue of Pipeline includes descriptions of three of the most common variations: Extended aeration, sequencing batch reactors, and oxidation ditches. The activated sludge plant is the most popular biological treatment process for larger installations.

Purpose

In a sewage (or industrial wastewater) treatment plant, the activated sludge process is a biological process that can be used for one or several of the following purposes: oxidizing carbonaceous biological matter, oxidizing nitrogenous matter: mainly ammonium and nitrogen in biological matter, removing nutrients (nitrogen and phosphorus).

Components

A basic activated sludge process consists of several interrelated components:

• An aeration tank where the biological reactions occurs.

• An aeration source that provides oxygen and mixing.

• A tank, known as the clarifier, where the solids settle and are separated from treated wastewater.

• A means of collecting the solids either to return them to the aeration tank, (return activated sludge [RAS]), or to remove them from the process (waste activated sludge [WAS]).

Process

The process takes advantage of aerobic micro-organisms that can digest organic matter in sewage, and clump together (by flocculation) as they do so. It thereby produces a liquid that is relatively free from suspended solids and organic material, and flocculated particles that will readily settle out and can be removed.

Bioreactor And Final Clarifier

The process involves air or oxygen being introduced into a mixture of screened, and primary treated sewage or industrial wastewater (wastewater) combined with organisms to develop a biological floc which reduces the organic content of the sewage. This material, which in healthy sludge is a brown floc, is largely composed of saprotrophic bacteria but also has an important protozoan flora component mainly composed of amoebae, Spirotrichs, Peritichs including Vorticellids and a range of other filter-feeding species. Other important constituents include motile and sedentary Rotifers. In poorly managed activated sludge, a range of mucilaginous filamentous bacteria can develop including Sphaerotilus natans which produces a sludge that is difficult to settle and can result in the sludge blanket decanting over the weirs in the settlement tank to severely contaminate the final effluent quality. This material is often described as sewage fungus but true fungal communities are relatively uncommon.

The combination of wastewater and biological mass is commonly known as mixed liquor. In all activated sludge plants, once the wastewater has received sufficient treatment, excess mixed liquor is discharged into settling tanks and the treated supernatant is run off to undergo further treatment before discharge. Part of the settled material, the sludge, is returned to the head of the aeration system to re-seed the new wastewater entering the tank. This fraction of the floc is called return activated sludge (R.A.S.).

The space required for a sewage treatment plant can be reduced by using a membrane bioreactor to remove some wastewater from the mixed liquor prior to treatment. This results in a more concentrated waste product that can then be treated using the activated sludge process.

Many sewage treatment plants use axial flow pumps to transfer nitrified mixed liquor from the aeration zone to the anoxic zone for denitrification. These pumps are often referred to as internal mixed liquor recycle pumps (IMLR pumps). The raw sewage, the RAS, and the nitrified mixed liquor are mixed by submersible mixers in the anoxic zones in order to achieve denitrification.

Sludge Production

Activated sludge is also the name given to the active biological material produced by activated sludge plants. Excess sludge is called "surplus activated sludge" or "waste activated sludge" and is removed from the treatment process to keep the ratio of biomass to food supplied in the wastewater in balance. This sewage sludge is usually mixed with primary sludge from the primary clarifiers and undergoes further sludge treatment for example by anaerobic digestion followed by thickening, dewatering, composting and land application.

The amount of sewage sludge produced from the activated sludge process is directly proportional to the amount of wastewater treated. The total sludge production consists of the sum of primary sludge from the primary sedimentation tanks as well as waste activated sludge from the bioreactors. The activated sludge process produces about 70–100 kg/ML of waste activated sludge (that is kg of dry solids produced per ML of wastewater treated; one mega litre (ML) is 10^3 m^3). A value of 80 kg/ML is regarded as being typical. In addition, about 110–170 kg/ML of primary ```sludge is produced in the primary sedimentation tanks which most - but not all - of the activated sludge process configurations use.

A variant of the activated sludge process is the Nereda process where aerobic granular sludge is developed by applying specific process conditions that favour slow growing organisms.

Recent Development

A new development of the activated sludge process is the Nereda process which produces a granular sludge that settles very well (the sludge volume index is reduced from 200-300 to 40 mL/g). A new process reactor system is created to take advantage of this quick settling sludge and is integrated into the aeration tank instead of having a separate unit outside. About 30 Nereda wastewater treatment plants worldwide are operational, under construction or under design, varying in size from 5,000 up to 858,000 person equivalent.

Life Cycle Cost Of Activated Sludge Process

It is observed that capital cost of Delawas Phase-1 plant is very low as compared to other ASP plants, this may be due to low quoted tender by the contractor. Electricity cost of Brahmpuri ASP plant is higher than that of other plants due to operation of Aerobic sludge digester (only plant in India) and extended aeration. LCC of Brahmpuri ASP treatment plant is also higher as compared to that of others due to aerobic sludge digester and extended aeration. The need for tertiary treatment has increased nowadays.

The Cost Per Mld For Asp Plants As Per 2011 Is Given Below In The Following Table:

S. NO.	COST (IN LAKH)	Delawas 1 (62.5 MLD) Jaipur	Brahmpuri 27 MLD Jaipur	Delawas 2 (62.5 MLD) Jaipur	Jaisinghpura Khor ASP, Jaipur 50 MLD	Salawas, Jodhpur 50 MLD ASP	Gajodharpura, Jaipur 30 MLD
1	Capital Cost	43.616	77.766	59.512	63.04	65.247	68.092
2	Electricity Cost	3.648	5.804	4.304	4.116	3.929	4.316
3	Maintenance Cost	1.1	1.379	1.259	1.289	1.341	1.367
4	Manpower Cost	0.26	0.398	0.28	0.33	0.368	0.382
5	Chemical Cost	1.9	2.874	2.3	2.413	2.511	2.596

The Cost Per Mld For Tertiary Traetment Plants As Per 2011 Is Given Below In The Following Table :

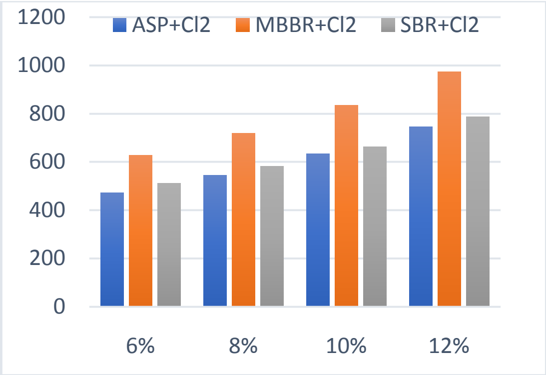
S. NO.	COST (IN LAKH)	Chlorination Treatment	UV Treatment	Ozonation Treatment	Hybrid disinfection A (Cl_2/O_3)	Hybrid disinfection B (Cl_2/UV)
1	Capital cost	3.0	13.320	18.650	11.488	10.168
2	Electricity cost	.220	.584	.688	.594	.567
3	O &M cost	3.642	5.690	6.013	5.395	5.145

The Lcc Of Asp For 20 Years (2011-2031)Is Given In The Following Table :

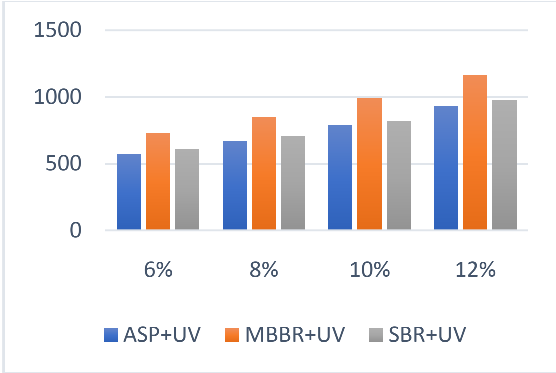
S. NO	ITEM	Delawas 1 (62.5 MLD) Jaipur	Brahmpuri 27 MLD Jaipur	Delawas 2 (62.5 MLD) Jaipur	Jaisinghpura Khor ASP, Jaipur 50 MLD	Salawas, Jodhpur 50 MLD ASP	Gajodharpura, Jaipur 30 MLD
1	20 year life cycle at 2031 Rs in lakh @6%	259.815	406.433	315.363	319.488	322.005	340.825
2	20 year life cycle at 2031 Rs in lakh @8%	291.911	455.009	353.196	357.346	359.868	381.067
3	20 year life cycle at 2031 Rs in lakh @10%	329.626	512.090	397.653	401.831	404.360	428.354
4	20 year life cycle at 2031 Rs in lakh @12%	373.936	579.152	449.855	454.097	456.633	483.911

Comparison Of Lcc Of Different Plants With Different Treatments:

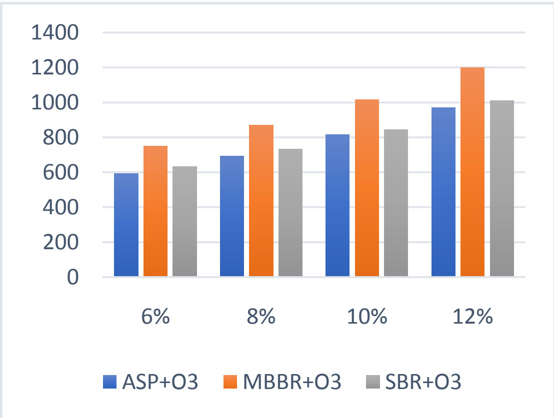
Capital cost of ASP is found to be lesser compared to MBBR and SBR plants because these plants are of higher capacity than the other plants based on SBR/MBBR technologies. After averaging the LCC values of all plants, electricity cost and O&M cost is found to be more for MBBR plants due to higher installed load of electrical units fitted but a lesser supervision is required. Chemical cost of SBR plants is found to be more as compare to MBBR as SBR plants have higher total suspended solids (TSS) in the treated effluent compared to the MBBR plants. LCC cost of MBBR is found to be more as compared to ASP and SBR technology due to high electricity cost and also being of lower capacity. Total LCC of ASP plant is less followed by SBR plants and MBBR plants. Treated effluent quality with respect to BOD is better in SBR plant among other treatment technologies. Land requirement for SBR and MBBR is less than ASP whereas the electricity requirement of MBBR is high in comparison to ASP and SBR.



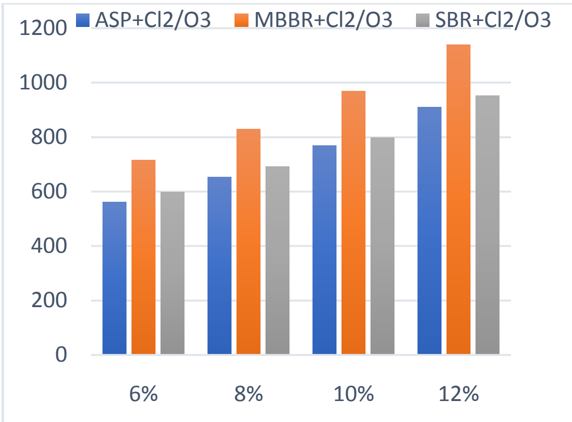
LCC of ASP, MBBR and SBR with Cl_2 Disinfection



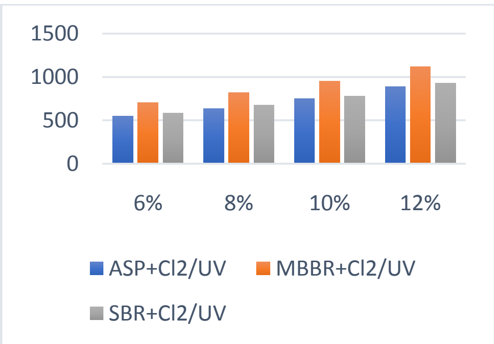
LCC of ASP, MBBR and SBR with UV Disinfection



LCC of ASP, MBBR and SBR with O_3 Disinfection (A)



LCC OF ASP, MBBR and SBR with Hybrid Disinfection



LCC OF ASP, MBBR and SBR with Hybrid Disinfection (B)

II. Conclusions

1. Activated sludge treatment process is widely used in the treatment of municipal sewage and industrial waste waters due to the fact that it's economically viable and reasonably safe to operate. Such a system can be used in large installations. However it's very important to have compatible design parameters to be infused while designing Activated Treatment Plant. Moreover, air requirement, MLSS, MLVSS, etc.

are very important parameters to be maintained in the system. The present paper deals with these aspects to impart an over view of the conceptualization along with system design.

2. This study shows that the effluent can be pure within the permissible level after a specific interval of time. The biological and chemical organisms can be reduced up to a large extent. It uses air (or oxygen) and microorganisms for wastewater treatment thus it is ecofriendly process and self-sustaining system. For small scale industry it can be the cost effective process. The effect of different parameters like temperature, pressure can be neglected as microorganisms can adapt surrounding environment, however it may affect the DO concentration. If sludge disposal can control by advanced technique then this process can be the most convenient biological process.

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