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"DOMESTIC WASTEWATER PURIFICATION IN UPFLOW BIOFILM SYSTEM WITH DIFFUSED AERATION"

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Key Wors:Wastewater Purifiction-Upflow miccobial film-System BOD-COD and TSS removal

ABSTRACT

The objective of this research was to conduct a bench scale study of fixed activated sludge treating domestic sewage.

Two different units employing diffused aeration with plastic and aluminum media were studied in four separate phases.

Data indicated that the system could produce a high quality effluent without any requirements for sludge recycling through the system. Suspended solids concentrations of 3-6 mg/l, BOD_5 concentrations of 4-12 mg/l and COD concentrations of 35-45 mg/l were found in the effluent with wastewater retentions ranging from 3-15hours, whereas an indication of nitrification was observed in higher detention periods.

As far as the type of media was concerned, the plastic and aluminum media did not differ significantly once the microbes had grown on the media.

INTRODUCTION

Adequate wastewater treatment is one of the major problems facing most of the developing countries including large and small communities of Iran. The developing countries lack sophisticated technology of wastewater treatme-

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nt, trained manpower, and in some cases economical conditions to overcome the problem.

Commonly, the small communities are utilizing mechanical, pre-constructed treatment plants. These treatment plants are generally extended aeration of contact stabilization activated sludge systems and both need close monitoring and attention(6).Unfortunately, municipalities are often unable to afford the necessary skilled operator and the lack of proper operation is one of the major problems facing small treatment plants. Another problem in these plants is their sensitivity to flow variations due to storm water and ground water infiltration which causes the systems to fail in many cases(5).

In contrast, it has been said that trickling filters were easier to operate than activated sludge and were less sensitive to shock loads (7)but they did not produce the desired effluent quality.

A fixed media activated sludge appears to offer a simple solution which mixes the merits of both activated sludge and trickling filter. The aerobic fixed media system has been examined from time to time over the years, starting with the early research of Buswell and Pearson 2) and the studies of Imhoff (3). The lack of understanding of biotreatment concepts resulted in the failures for the early fixed media systems. It was not until 1960's that an effort was made to examine fixed media systems with adequate air (4).

The major objectives of this studies were:

1. To determine the feasibility of the proposed fixed activated sludge for treatment of domestic sewage and,
2. to determine the biochemical characteristics of the system under several different hydraulic and organic loading conditions.

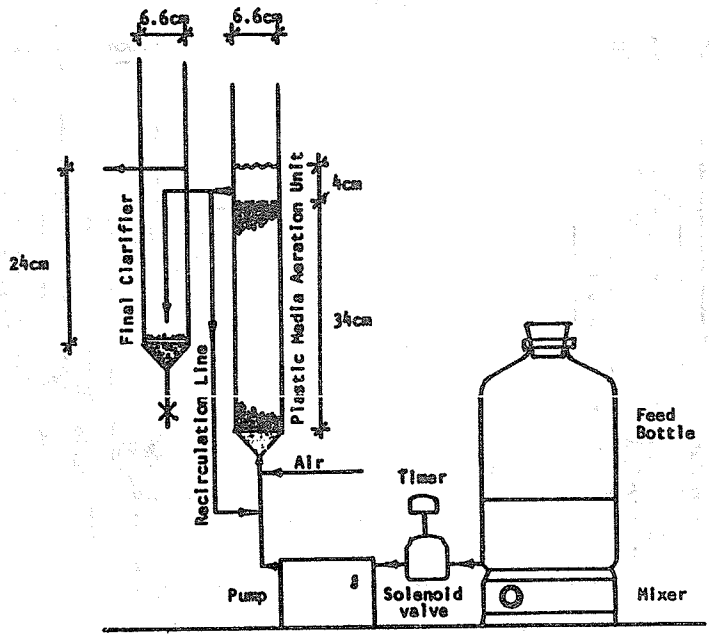
MATERIALS AND METHODS

A fixed activated sludge unit was constructed from a clear plastic tubing and was filled with plastic flex-rings.The sewage was pumped from feed bottle to the bottom of the fixed media unit by a peristaltic pump which was operated on an intermittent basis by a timer arrangement. The pump was operated once every 10 minutes. The length

of the pump cycle was adjusted to the desired flow rate . Air was added to the fixed media unit through a glass "T" located just below the unit. The air was obtained from the laboratory air supply and controlled at a fixed rate with an air flow monometer. A return supernatant line from the fixed media effluent port was attached to the air and feed line. The aeration system actually created an air lift pumping action that continuously mixed the fluid around the fixed media unit. Figure 1 illustrates the plastic media activated sludge which was operated as an upflow system.

After two phases of the study another fixed media unit with aluminum media was constructed and operated along

FIGURE 1

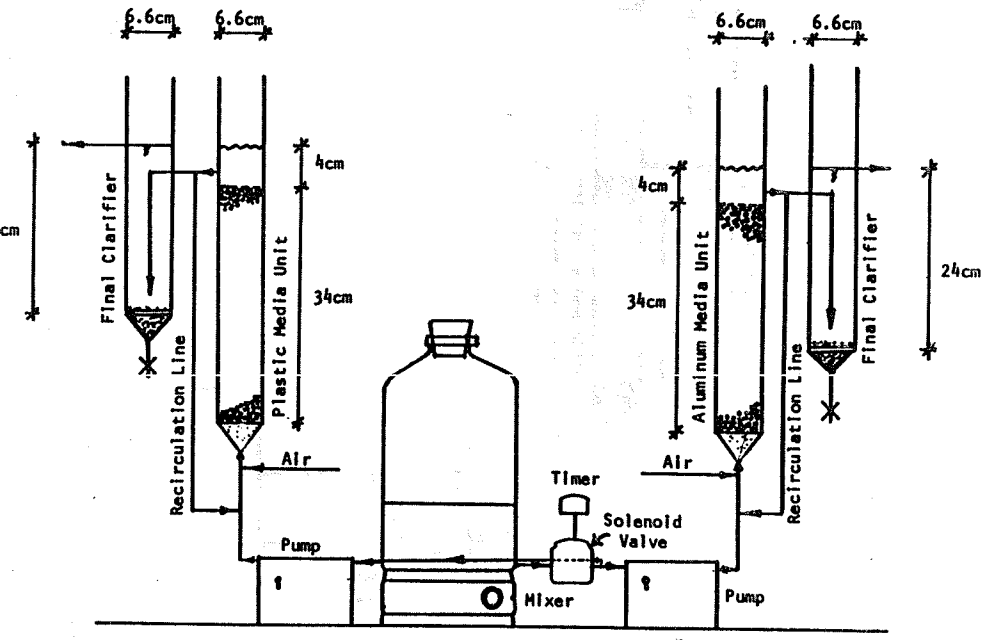


Schematic Diagram of Fixed Media Activated Sludge System (Plastic Media)

with the original unit, Figure 2. In all phases the fixed media unit was followed by a final clarifier. Table 1 shows the physical characteristics of different units under study and Table 2 summarizes the operational procedures of different phases during this research.

The system was operated enough to reach steady conditions before data collection in each phase. Samples were taken from influent and final effluent in regular intervals. Suspended soleds, BOD_5, COD and total alkalinity were the major parameters analyzed for the collected samples and microscopic examination of the flocs was conducted from time to time. All analysis were made according to procedures given in Standard Methods (1).

FIGURE 2



Schematic Diagram of Fixed Media Activated Sludge System (Plastic Media & Aluminum Media)

Table 1: Description of Units Under Study

Physical Characteristics of Units	Aeration Units		Clarifiers
	Plastic	Aluminum	
Construction Material	Plastic	Plastic	Plastic
Unit Dimensions			
Inside Diameter, cm	6.6	6.6	6.6
Water Depth, cm	38	38	24
Effective Depth, cm	34	34	24
Number of Medium	225	96	--
Medium size. Inch	5/8	5/8	--
Media Total Volume, cm^3	135	144	--
Effective Zone Volume, cm^3			
Without Media	1163	1163	821
With Media	1028	1019	--
Porosity Media	0.88	0.87	--

Table 2: Summary of Operational Conditions

Phase No.	Retention Time Hours	Substrate Fed	Media Type	Operational Period, days
1	15	Settled Sewage	Plastic	45
2	9	Settled Sewage	Plastic	44
3	5	Settled Sewage	Plastic & Aluminum	67
4	3	Settled Sewage	Plastic & Aluminum	55

RESULTS

The COD removal characteristics of the FAS during the study are indicated in Table 3.The results show that a large portion of the influent COD was removed by the system. A mean total COD reduction of 78 to 90 percent was gained with plastic media unit. While, the aluminum media unit reached a COD reduction of 81-83 percent.The poorest COD reduction for plastic media unit, 78%,was experienced in the first phase where because of low influent BOD_5 microbes could not stick firmly to the media . Overall effluent COD concentrations of 35-44 mg/l were observed with plastic media unit whereas the aluminum media unit showed somewhat higher effluent COD concentrations. The suspended portion of the effluent COD was relatively low in all cases which was in agreement with effluent suspended solids data.

The plastic media unit was very efficient in BOD_5 removal. As can be seen from Table 3 effluent BOD_5 concentrations in plastic media unit ranged form 3.7 to 11.2 mg/l. Maximum effluent BOD_5 occurred in phase 4 when the aeration time was reduced to 3 hours. The aluminum media unit produced an effluent BOD_5 of 20.7 mg/l in its first tun of operation.This high BOD concentration corresponded the effluent soluble COD at the same run indicating the unmetabolized organics in the effluent. Once the optimum level of bacterial population was achieved,the system remained stable and effective in removing BOD_5. In phase 4 the aluminum media unit produced an effluent BOD_5 of 12.1 mg/l in comparison with 11.2 mg/l for plastic media unit which showed not much of difference between the media types.

A consistently clear effluent was produced by the FAS as can be seen from SS data presented in Table 3.Effluent SS represents the biomass produced by the biological process in the system. It can be seen that the effluent SS concentrations were below 6 mg/l in all phases and were independent of influent suspended solids in the range of normal conditions of domestic sewage. In second phase of the study the influent TSS reached its maximum of 213mg/l approximately 3 times of the influent TSS in other cases. The effluent TSS in the second phase was 5.2 mg/l which

Table 3: Summary of the Results

	Phase 1	Phase 2	Phase 3		Phase 4	
			Plastic	Aluminum	Plastic	Aluminum
Total COD						
In	188	366	307	307	269	269
Out	41	35	36	58	44	47
% Removal	78	90	88	81	84	83
Soluble COD						
In	73	113	220	220	193	193
Out	32	24	30	48	39	43
5 Removal	56	79	86	78	80	78
Suspended COD						
In	115	253	87	87	76	76
Out	9	11	6	10	5	4
% Removal	92	96	93	89	93	95
Total BOD_5						
In	85	156	152	152	132	132
Out	3.9	3.7	5.6	5.6	11.2	12.1
5 Removal	95	98	96	97	92	91
TSS						
In	82	213	75	75	62	62
Out	3.5	5.2	2.4	5.1	4.0	3.4
% Removal	96	98	97	93	94	94
VSS						
In	60	149	58	58	50	50
Out	2	3.8	1.8	4.6	3.6	3.1
% Removal	97	97	97	92	93	94
NVSS						
In	22	64	17	17	11	11
Out	1.5	1.4	0.6	0.6	0.4	0.3
% Removal	93	98	96	96	96	97
Total Alkalinity						
In	---	202	196	195	173	173
Out	---	114	116	174	150	160
Removal mg/l	---	88	79	21	23	13

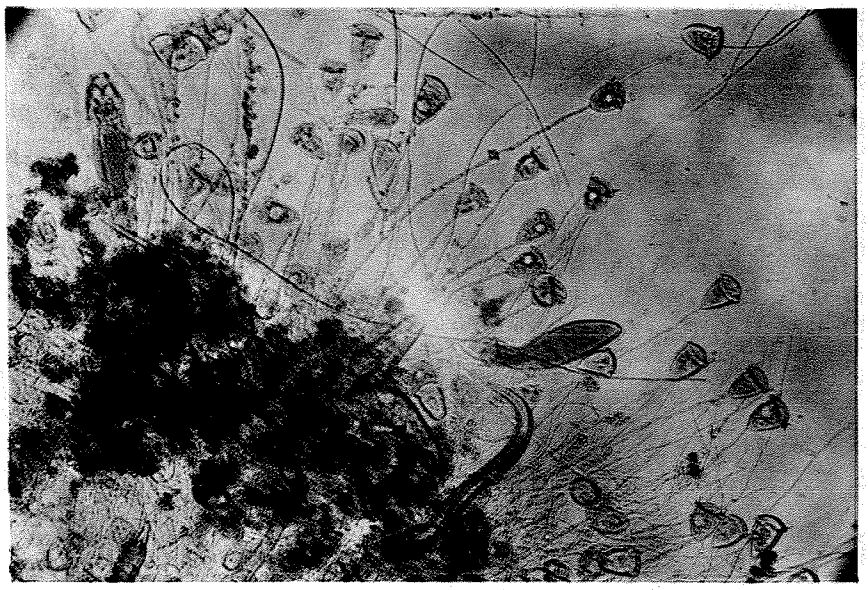
was not significantly different from the effluent TSS in other cases. The effluent TSS in the second phase was 5.2 mg/l which was not significantly different from the effluent TSS in other phases. With regards to TSS removal the plastic media and the aluminum media showed almost the same efficiency. Although in phase 3 the aluminum media showed lower percent removal of TSS it was improved in phase 4 where the system was in more equilibrium state . With low organic loadings like in the first phase the biological solids were unable to stick to the media and were loosely dispersed in the pores. At the beginning it was thought that the looseness of microbes was because of the same electrical charge of the bacteria and of the plastic media but in phase 2 with the increase of organic loading, microbes became more active and adhered the media.

Microscopic examinations of biological flocs showed typical activated sludge micro-organisms. At the time of low soluble food examination of the flocs showed a large number of dead cells which were believed to be the remains of protozoa and rotifers indicating a low population of bacteria; but at other times a very active biomass was observed. Large number of free swimming ciliated protozoa mostly Stylonychin and some Paramoecium, many stalked ciliates, Vorticella, many rotifers, predominately Philodina , some amoeba and some nematodes were present in each sample. The bacteria were filamentous and the liquid at the top of the media was normally clear. In phase 4 with 3 hours of aeration time the population of stalked ciliated protozoa decreased and a large mass of worms with red spots on their body were observed in the flocs. Figures 3 to 8 show the photomicrographs of typical microbes of FAS.

DISCUSSION

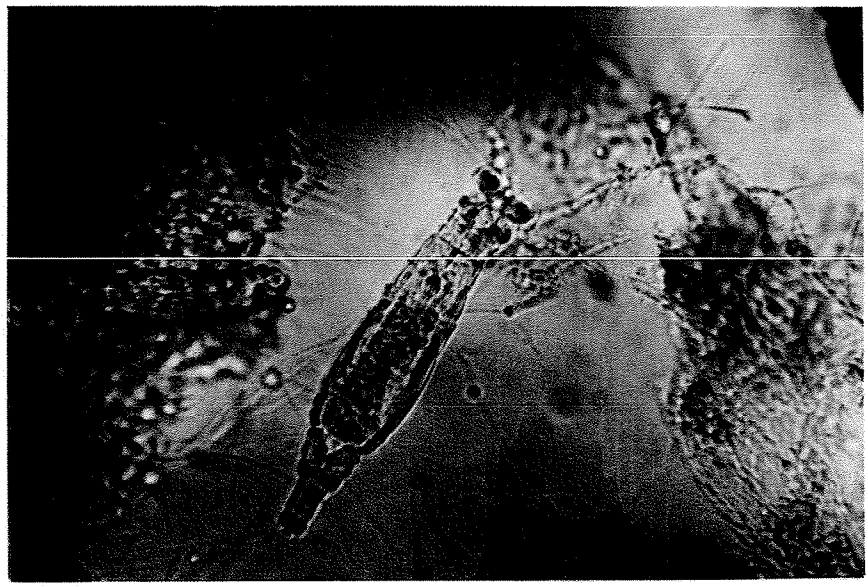
This study provided data on treatment of domestic sewage at relatively low organic loading rates . Primary effluent was used to minimize excess solids in the system It quickly became apparent that primary effluent could be treated to a very high degree with minimum of excess microbial solids accumulation. Normal solids recirculation

Figure 3



Photomicrograph of Stalked Ciliated Protozoa Typical for the Aerobic Plastic and Aluminum Media Units

Figure 4



Photomicrograph of Rotifers Typical for the Aerobic Fixed Media Units

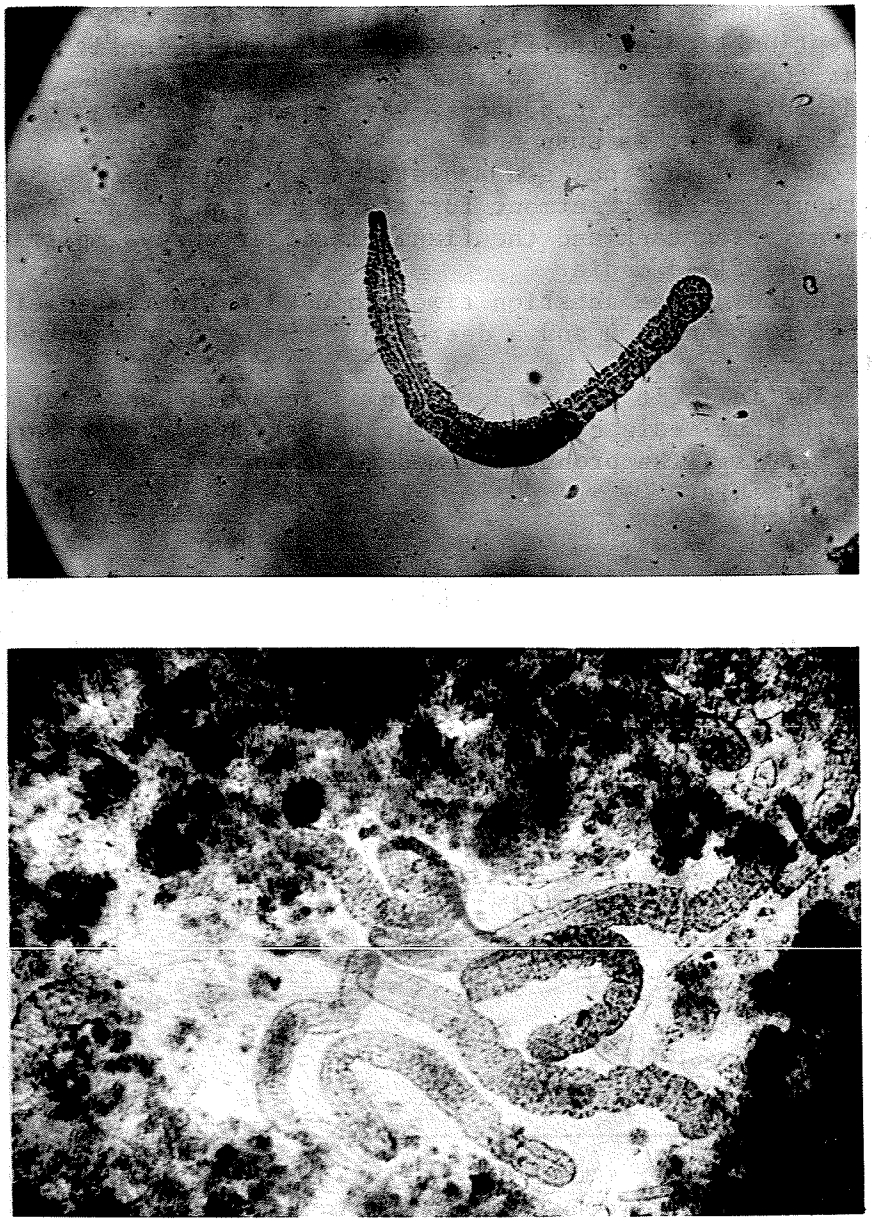
Figure 5

Photomicrograph of Filamentous Bacteria Typical for the Aerobic Fixed Media Units

Figure 6

Photomicrograph of Free Swimming Protozoa and Rotifers Typical for the Aerobic Plastic Media Unit

Figure 7



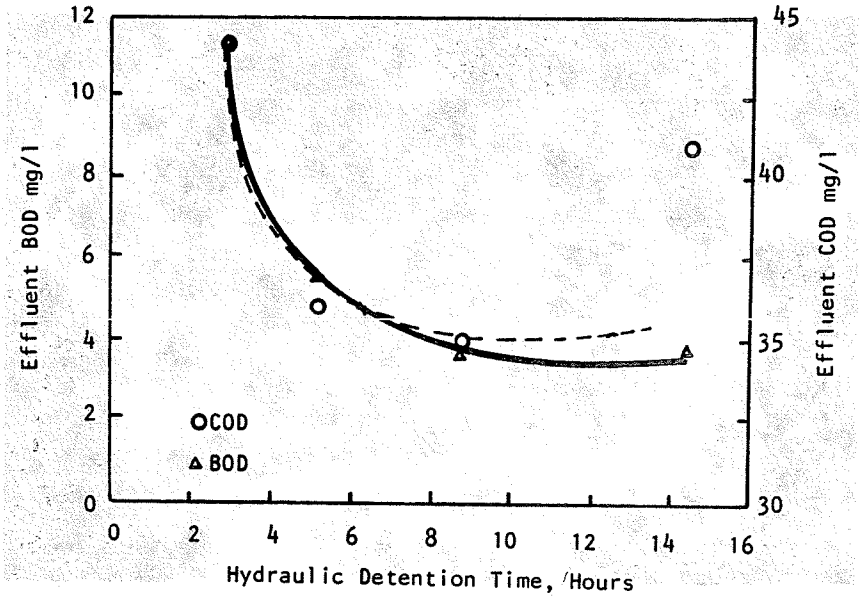
Photomicrographs of Large Worms Typical
for the Fixed Activated Sludge Units

was not required with the FAS as it was with normal activated sludge. In fact, it was observed that the solids retention time on the fixed media was sufficiently long that the excess solids were aerobically digested.The final sedimentation tank produced a very clear effluent with a minimum of excess suspended solids. The solids which accumulated in final sedimentation tank would be wasted without further treatment for its organic portion. Thus , the aeration tank and the final clarifier were simplified with the fixed media.

Reducing the aeration time produced an increased effluent BOD_5 and COD and a decrease in removal percentage, figures 9 and 10.

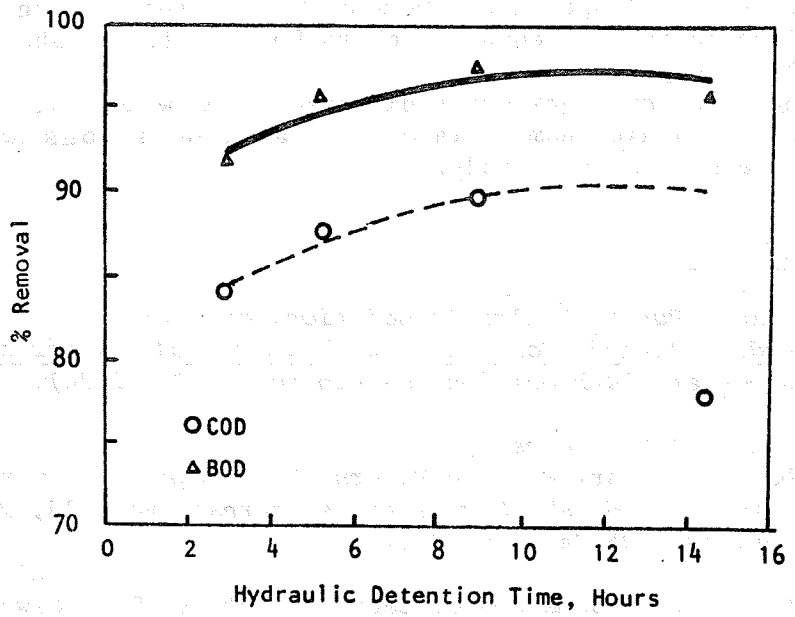
Initially,it appeared that plastic media was superior to aluminum media but subsequent operations gave comparable results. The problem seemed to be one of acclimation to the media.

Figure 9



Effect of Detention Time on Effluent Total BOD_5 and Total COD

Figure 10



Effect of Detention Time on BOD_5 and COD Percent Removals

The FAS produced to some extent a nitrified effluent especially in higher aeration periods. The degree of nitrification was measured by the change in alkalinity, Table 3. As the retention period was reduced, the apparent nitrification decreased. The decreased retention period in the aeration unit resulted in more rapid building of the normal bacteria and prevented the nitrification reaction from proceeding to completion.

CONCLUSIONS

The following conclusions were obtained from this research:

1. The fixed activated sludge system employing diffused aeration appears to be a suitable method of domestic wastewater treatment in areas lacking skilled op-erators.

2. Sludge recirculation can be eliminated with the fixed activated sludge since the microbes are retained on the fixed media in adequate numbers for rapid metabolism of the organic wastes.
3. There was no significant difference between plastic media and aluminum media as far as operations were concerned in this study.

REFERENCES

1- *American Public Health Association, et al.: Standard Methods For The Examination of water and Wastewater, 14th edition, Washington, D.C. (1976).*

2- *Buswell, A.M.: Peacson, E.L: "The Nidus(Nest) Rack, a Modern Development of the Travis Colloiders". Sewage Works Journal, Vol. 18, No. 2, pp. 187-195(January 1926).*

3- *Imhoff, K.: "Submerged Contact - Aerators for Sewage Treatment". Engineer News Record, Vol. 97, No.24, pp. 948-949. (December 9, 1926).*

4- *Kato, D. and Sekikawa, Y., " Fixed Activated Sludge Process for Industrial Waste Treatment". Journal Water Pollution Control Federation, Vol. 44, No. 3, pp. 401-413(March 1972)*

5- *Mckinney, R.E.: "Techniques for Evaluation of Operational Data from Activated Sludge Plants",Presented at 53rd Annual Water Pollution Control Federation Conference, Las Vagas, Nevada. (Oct, 1980).*

6- *Metzler, J.A.: :An Investigation of Package Activated Sludge System in Southeast Kansas". Transactions of the 30th Annual Conference on Sanitary Engineering , University of Kansas, Lawrence, Kansas(1980).*

7- *Wisely, Witt.: "Trickling Filters". Sewage Works Journal. Vol. 9, No. 3, pp. 513-515.(May 1937).*