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Performance of small sewage works in Tehran

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INTRODUCTION

United Nations figures indicate that more than 70 percent of world's population live in countries known as "developing". They vary a great deal in aspects such as economic status and per capita income, technical capability, education and rate of illiteracy, nutrition and other markers which explain the degree of "developing". However one familiar characteristic, common to most of them, is over population in cities which can not provide them with basic necessary services. Mexico city, Cairo, Amman and Tehran are good examples. Rapid increase in population over relatively short period of time has created situations where proper sanitation is often non-existent and safe water supplies is out of reach for the poor.

Tehran is a city where one out of every six Iranians live there, with nine million people. Fortunately the water supply for its inhabitants is of high standard and over 90 percent of them benefit from own water taps. But proper sewage disposal which is a basic necessity for a modern city is not satisfactory.

Due to the lack of a collection-treatment system other methods are implied, including the use of package plants and small treatment works, which usually suffer from poor performance and are open to objections.

SEWAGE DISPOSAL SYSTEM

The traditional Iranian house has two shallow wells for sewage disposal. Each well, constructed near the main building is usually 1 to 2 meter wide and 10 to 15 meter deep, leading to a larger space of 20 to 50 cubic meters. One well is used for stronger lavatory wastes while the other receives wash waters and week kitchen's effluents. The well acts as a system where water passes through underground soil and solids undergo anaerobic digestion, thus the sewage is disposed of with minimum effort. For areas where soil is of sandy nature and the quality and quantity of wastewater is not objectionable, little attention is required for satisfactory operation of this system. But in the case of industrial wastes and where water percolation is slow due to the nature of the soil wells do not operate satisfactory and frequent discharge and emptying is necessary.

During the past two decades large blocks of apartments and high concentrated dwellings has dominated Tehran and the replacement of wells with package treatment plants and small sewage works has become inevitable.

Large communities have the required land and space so prefer to benefit from small but conventional treatment plants. Smaller areas small industries, hospitals and hotels go for prefabricated package plants. These plants consist of different types, from basic septic tanks to full activated sludge systems, but it seems that the latter type is growing in demand due to higher standards of effluents required by health authorities. Activated sludge package plants are easy to construct and at least on the paper are capable of producing effluents of very high standards. The owner of the package plant is often told that he could use the effluent of the plant to water the green area and the garden. But unfortunately this is not so in practice as the performance of these plants are very much a matter of good maintenance, proper design, and skilled operation. The present study looked into the performance of three package plants and a small conventional works. It is hoped that the findings of this study will help to pinpoint the difficulties and to make suggestions for improvement.

SCOPE OF THE STUDY

Three package plants of different sizes, marked A, B and C investigated in this study were those belonging to a building complex a large hotel and a manufacturing factory without any industrial waste. The plants were receiving 20, 50 and 80 cubic meter per day respectively (design figures). Plant D which served a community of 500 flats, was a conventional small plant. All plants A, B, C and D were activated sludge type systems designed on extended aeration principles. Frequent samples were taken from inlet and outlet of the plants as well as samples from the aeration tanks. The time of the sampling was mostly during the spring time were the climate and the ambient temperature was favourable. Samples were analysed in BBRC Sharif

University laboratories according to standard methods of analyses.

RESULTS

Table 1 shows the information which was available on these plants. Plants A, B and C were pre-fabricated from metal sheets, and plant D was a typical concrete structure. The effluent of all plants although expected to be used for watering the garden, was discharged to sub-soil infiltration, and percolation.

Table 1

Plant	Type	Design ₃ cap. m ³ /d	Aver. flow	Aeration tank m ³
A	Diff. Aer.	20	24	20
B	Diff. Aer.	50	60	50
C	Mech. Aer.	80	85	80
D	Mech. Aer.	400	420	380

Summary of the laboratory results of the samples taken at random intervals are shown in table 2. Each figure is the average result of at least six acceptable samples. Samples taken at the times of system breakdowns or other irregular functioning were considered unqualified and not used in the study.

As it can be seen from table 2, the performance of the three plants A, B and C are poor but that of plant D is comparatively better.

Plants A and B relied on diffused aeration system for provision of oxygen to the aerated tank. Return sludge was also carried out by air lift technique. Plants C and D were using surface aeration and sludge return was obtained by sludge centrifugal pumps. There was little to choose from the diffused air or mechanical surface aeration systems, but more frequent blockage and breakdowns were recorded for the plants using diffused air mechanisms.

The centrifugal sludge pump responsible for transferring the sludge to aeration tank or to sludge silo often proved to be unreliable. These are noted by satisfactory levels of DO in aeration tanks and low concentration of mixed liquor suspended solids which represent the viable bacteria. Problems of sludge bulking were frequently observed in the first three plants, and excessive foaming was another matter of concern.

Plant D which was attended regularly by a technician was more promising. It was difficult to state that better design or better operation is responsible for more reasonable performance but both factors are considered equally important.

Table 2

Plants	A	B	C	D
<u>Influent</u>				
pH	7.2	7.1	7.2	6.9
SS	260	235	210	180
Tot.Solids	950	920	850	840
BOD ₅	275	290	220	195
COD	420	410	390	380
Tot.N	36	38	32	40
Tot.P	50	55	58	43
DO	4.5	4.0	5.1	2.8
<u>Aeration Tank</u>				
pH	7.5	7.0	6.8	6.9
MLVSS	600	750	690	1050
MLSS	680	850	760	1340
DO	1.5	0.5	3.0	2.5
<u>Effluent</u>				
pH	7.5	7.1	7.0	6.9
SS	80	60	120	45
BOD ₅	120	135	115	35
COD	270	290	165	96
Tot.N	30	30	24	23
Tot.P	41	42	41	40

All figures except pH are in mg/l .

Low rates of BOD and COD removal observed, particularly in the first three plants could be as a result of high loading, food to microorganism ratios. F/M of the four plants were 0.55, 0.46, 0.34 and 0.21 day⁻¹ which is high for extended aeration operation showing organic overloading is occurring. However the main reason behind this characteristic is low levels of MLVSS and the incapability of the plants to maintain a high mixed liquor volatile suspended solids. Factors such as sludge bulking, hydraulic overloading and flow surges causing sludge washout and harmful chemicals in the raw sewage are major contributors to a low level of MLVSS found in the aeration tank. Comparing the performance of the four plants plant D was more stable and producing better results, reducing over 80 percent of the organic load shown by BOD₅ results. None of the plants affected the concentration of nitrogen or phosphates as required by modern standards and indeed all four failed to reach Iranian standards for treated sewage disposal. The disposal of excess sludge which was expected to be a matter of importance was not observed here due to lack of sludge accumulation. But it was understood that sludge

disposal is usually one of the difficulties facing the operators of the package plants. Overall comparison of the four plants studied indicated that small conventional treatment plants could be better operated and could produce effluents of higher quality. In terms of capital investment too, one small concrete plant is more advantageous than several pre-fabricated package plants doing the same job. But the land requirement and disposal of the treated sewage is a factor to be considered in already developed areas of the city.

The reasons behind the poor performance of the package plants studied are classified in at least three sections:

- a- Technical aspects
- b- Operation and maintenance
- c- Design considerations

TECHNICAL ASPECTS

Small activated sludge plants, particularly of the package type are often subject to technical difficulties, some of which are listed here:

-Variations in the strength and the flow of sewage is often a characteristic of package plants. There is a misguided belief among some that a package plant can somehow mysteriously cope with such extreme variations in loading, where a conventional biological sewage plant can not. This is not so and shock loads cause problems such as washouts and overloadings.

-Flow of toxins and chemicals impose shocks to microorganisms in the aeration tanks. Use of chemicals such as bleaching agents and strong detergents is quite common in modern life and due to small flow of sewage, they inflict a strong influence on the activity of the microbial cultures. Sludge bulking, low MLVSS are often the result of unhealthy environment of the aeration tank.

-The number, activity and variety of bacterial species is a point often neglected. The climatic and geographical environments are bound to have severe effects on the growth, transfer and even the maintenance of the microbial life. The sources of microorganisms for biological wastewater treatment are mainly the soil, the air and the stream water, and without a large enough variety of microorganisms it would be extremely difficult to maintain an adequately stable ecosystem in a purification plant. No data was available in the number of bacterial count of the units investigated, but a previous study had shown that there are only

4-6 genera present in such package plants where viable bacteria were found to be in the order of $1.5-6 \times 10^7$ per ml of mixed liquor in the aeration tank. These figures indicate that the number of genera and bacterial count is low by all standards.

-Plant loading, particularly BOD/MLVSS is another parameter which is difficult to control in small units. Although the design specifies loadings well within the acceptable range but most small plants cannot reach their expected values.

OPERATION & MAINTENANCE

Activated sludge package plants which are often of extended aeration type, are sensitive to oxygen level and concentration of mixed liquor suspended solids. Routine periodical quality control of the effluent must be carried out by determination of : settleable solids, pH, COD, suspended solids and other parameters which could control the biological balance in the system. Other controls which must be carried out regularly include:

-Daily removal of gross solids to prevent the sewage from backing up.

-Daily removal of grit which if neglected may lead to closure of the plant when this enters openings and block valves and pumps.

-Regular maintenance and lubrication of all pumps, blowers and valves and indeed all moving parts is essential.

-Removal of excess sludge, or digested sludge to keep the site clean.

-Renewal of chlorine solution and other chemicals if necessary.

-Checking the electrical switches and circuits.

-It is invaluable to keep a plant record card and register the maintenance schedules of the plant. Unfortunately this aspect of the operation is almost always neglected by plant owners in developing countries.

-Painting will help to protect the bare metal surfaces from corrosion. It also makes a presentable appearance of the unit. It is therefore essential to paint all metal parts at least once every two years.

DESIGN CONSIDERATIONS

The design of small sewage works including package plants must provide for and take into account a number of parameters such as:

- Simplicity of operation requiring minimum maintenance.
- Considerations for low impact on local amenity including smell and fly nuisance , provisions for hygienic disposal of sludge by tanker for which loading facilities must be available.
- Considerations for construction and maintenance at reasonable cost, including fast repairs and minimum shutdowns.
- Site considerations including a safe working place adequately fenced.
- Provisions to take into account large variations in flow, the smaller the number of community served the greater the variation will be.
- Considerations for proper disposal of treated effluent, including the study of underground water tables to prevent the pollution of water. It is imperative that in many communities drinking water is drawn from wells near the site of treatment works.
- Other factors which must be considered include the availability of power supply , skilled manpower, particulars of effluent requirement and other parameters which could be important for an owner or operator of package plants or small treatment works.

CONCLUSIONS

Having completed all the preliminary investigations, the first step for a designer is process selection. There are a number of different types of package plants, requiring a wide range of capital and operating costs. The most frequently used treatment options found in Tehran are septic tanks and activated sludge units. Septic tanks do not produce effluents to meet the current standards so the choice is often limited to activated sludge package plants. However the present study indicated that activated sludge package plants could be as inadequate as septic tanks. On the other hand small conventional type of plants usually benefit from better attendance and could thus operate in a more satisfactory manner. Unfortunately their application is limited due to higher costs and land demand.

Increasing needs for better sanitation in Tehran (indeed most cities in developing countries) indicate that the number of small plants, conventional or package, will grow in future. But it is also expected that more stringent regulations of effluent discharges will also be applied. The designers and engineers are therefore faced with a very interesting and challenging situation to provide basic engineering for pollution control. The rewards could be high in terms of better sanitation for millions of people and impact in terms of economical values.

REFERENCES

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