COMMENTS CONCERNING THE RECLAMATION OF HOFUF SEWAGE TREATMENT PLANT AND THE AL-HASSA IRRIGATION AND DRAINAGE PROJECT

SEPTEMBER, 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

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I. RECOMMENDATION FOR THE RECLAMATION OF HOFUF SEWAGE TREATMENT PLANT EFFLUENT

1. Foreword

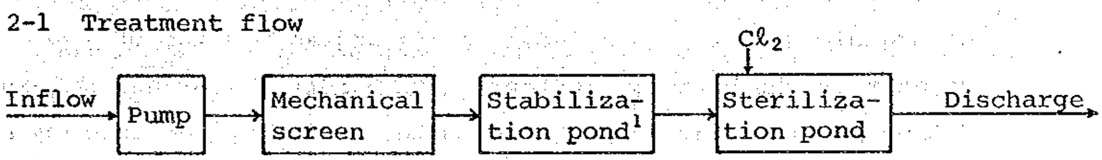
The mission for the consultation to the above described purpose visited the Hassa Irrigation and Drainage Authority (HIDA) on June 18-21, 1980.

Mutual discussion between HIDA and the mission and also careful survey of the existing Hofuf Treatment Plant was conducted aiming at the reclamation of treated sewage mainly for irrigation.

This report is prepared by the mission based on the study of results obtained through the site visit and experimental consideration which is necessary to fill up the unfortunately insufficient data on the existing plant performance and design criteria.

2. Outline of the Existing Treatment Plant

2-1 Treatment flow



Note 1: The most common name, Stabilization Pond, is used here to denote the pond which plays the main role in treatment. Though it is referred to as the Septic pond at the HIDA, strictly speaking, it should be called Facultative lagoon. Principles of treatment will be described later.

2-2 Outline of the facilities

Though details are not available, the existing facilities may be outlined as below according to the data obtainable.

a) Volume of water to be treated: maximum 15,000 m^3/d.

b) Stabilization pond:

Total surface area: 40 ha
Depth : approximately 2 m

Number of ponds : 4

Aeration facilities: none

c) Water quality: unknown for both inflow and outflow.

2-3 Mechanism of treatment

In order to clarify problem areas, the mechanism of treatment is outlined below.

The sewage from which solids in large size have been removed by screen flows into the pond; suspended solids will then deposit at the bottom. At the surface layer of the pond, oxygen dissolves into water both from atmosphere and through photosynthesis reaction by algae grown in water. As a result, aerobes multiply through the biological reaction to take and decompose dissolved organic matter together with dissovled oxygen and discharge CO_2 which is then consumed by algae in photosynthesis reaction.

In the bottom layer, on the other hand, there is much amount of organic matter as suspended solids and as remains of algae deposit at the bottom. Further, with hardly any oxygen the condition is anaerobic and organic matter is decomposed into organic acid, CO_2, methane, etc. by anaerobes. Organic acid produced as a result of anaerobic decomposition becomes the object of decomposition by aerobes near the surface layer and CO_2 is used in photosynthesis. In other words, organic matter in the waste water is decomposed by anaerobes and aerobes in the pond and most of them find their way into the cells of algae through resynthesis by photosynthesis and then into the treated water.

Accordingly, an important point in this method of treatment is that there should be balance between the decomposition of organic matter by bacteria on the one hand and required supply of oxygen by photosynthesis on the other. However, quantitative handling of these biochemical reactions is by no means easy and the growth of algae is largely influenced by external environment, particularly by the sun beam density. Therefore, no theoretically unified approach has been established. In any case, it may be said that unless algae is removed from the treated water, the quality of treated water is still at the preliminary stage of treatment in biochemical treatment.

3. Problem Areas of Existing Treatment Facilities

As the objective is to use the treated water for irrigation, the above-mentioned process adopted at the existing treatment plant poses several problems.

3-1 No function of removing algae

As has been described in 2-3, most of the organic matter in the sewage is converted to cells of algae. However, since there are no facilities to remove them, they are discharged with the treated water. Consequently SS and BOD contents in the treated water are high and sterilization requires much amount of chlorine.

Further, dead cells of algae deposit and rot in the low velocity current of the waterway; they also cause clogging in soil of the field, reducing permeability. Rotten cells of algae produce bad odour; in some cases it is even possible that hydrogen sulfide produced has an unfavorable effect on crops.

3-2 With high evaporation of water, the density of dissolved salts increases

In general, ground water in this area has a high salt density of 1,000-1,500 mg/ℓ. Accordingly, even when the ground water is directly used for irrigation, some steps such as frushing of salts in the field is required. Untreated sewage is estimated to have a similar salts density.

Further, since the current treatment plant uses the theory of facultative lagoon which requires a large surface area, evaporation from the water surface is extremely large; concentration due to evaporation cannot be ignored. With the evaporation rate of 18 mm/d, the total water loss due to evaporation from the total area of the treatment pond (40 ha) is estimated as follows:

$$0.018 \text{ m/d} \times 400,000 \text{ m}^2 = 7,200 \text{ m}^3\text{/d}$$

This is equivalent to as much as 48% of the sewage inflow of 15,000 m^3/d. Accordingly, the salts density of the treated water is higher than the untreated sewage by 1.92 times. If the salt density of the sewage is 1,500 mg/ℓ, it will be 2,880 mg/ℓ in the treated water; the use of the treated water for irrigation may thus seriously be limited to some particular crops.[1)]

Further, it should be remembered that a total of 7,200 m^3/d among 15,000 m^3/d can not be recovered and lost.

3-3 Heavy metals cannot be removed

As for the influence of heavy metallic salts contained in the irrigation water, they may work in two ways: 1) direct influence such as hampering the germination and growth of crops; and 2) effect on human body by taking them trapped in the food.

Whether heavy metallic ions are contained in the sewage or not is unclear at present. However, if the waste water from metal finishing plant, tanning plant, chemical plant, etc. is discharged into the sewerage, there is plenty of possibility of heavy metals finding their way into the sewage.

Further, in a hot and dry area such as the area in question, the concentration in the field during irrigation should be taken into consideration.

In general, when the sewage is biochemically treated, heavy metals are concentrated in biological cells. It is reported that when treatment is carried out with fully functional activated sludge, the density of heavy metals such as mercury, cadmium, zinc, etc. in biological cells reaches an equilibrium at 4,000-10,000 times of concentration in the surrounding water.[2)]

However, under the current method of treatment, those biological cells germinated during the process either accumulate in the pond not being discharged outside the treatment system or are discharged with the treated water. Since those biological cells accumulated in the pond will rot and decompose, those heavy metals in them will be eluted again; thus the removal of heavy metals during the process of biological treatment cannot be expectable.

3-4 Incomplete sterilization

In the present treating plant, the effluent of the stabilization pond is directly chlorinated in the sterilization tank without solids separation.

As high organic solids concentration causes high chlorine consumption, dosing rate of chlorine should be kept at high level to sterilize the effluent, or defficiency of chlorine will often occur and it will cause incomplete sterilization.

The other hand, during the chlorine sterilization process, various kinds of organic chlorides are produced, and some of them, e.g. trihalo-methane are pointed out to have toxic effects on human bodies.

Therefore, when the reclaimed sewage is used for irrigation, especially in such a case where the reclaimed water has a possibility to be used for drinking, these problems should be studied including the necessity of changing the sterilization agent.

3-5 Nutrient salts

When the sewage is used for irrigation, particularly for grain, with the existence of excessive nitrogen compounds, it may lead to overgrowing and hamper fruiting. This phenomenon often poses a problem in Japan with paddy rice. In the area concerned, however, since frushing of soil is an indispensable condition, nutrient contents will be washed off, the possibility of excessive nutrition seems to be small.

4. General Conception for the Improvement of Facilities

4-1 Basic approach

In the previous chapter the problem areas of the existing facilities were outlined. As regards the improvement plan, a conclusion has to be reached after comprehensively studying the factors mentioned below.

A. Objectives of reuse: one of or any combination of those listed below.

i) Object crops (is it for general irrigation or specific crops?)

ii) Use as drinking water for cattle.

iii) Use as washing water for crops.

B. Quality of the water treated by the existing facilities and evaluation of its effect on objectives

i) Amount of algae and the method for removing them.

ii) Salts density and the method to reduce salts.

iii) Kinds and quantities of heavy metals and the method of removing them.

iv) Hygienic safety and measures.

C. Possibility of blending with water from other sources

i) Will the treated water be used by itself?

ii) Can it be blended with the existing irrigation water? If so, its quality and quantity.

iii) Can it be blended with water from sources other than the irrigation water?

D. Conditions of location

i) Relative positions and conditions of location in respect to the existing sewage treatment plant, the site of the proposed treatment plant for reclamation and the place of using the recovered water.

ii) Will a special waterway be used? Or, will the existing waterway be used?

Since these factors are closely related to one another, actual improvement measures can be formulated only after they will be ascertained. However, since the data available are insufficient, we have to be satisfied with presenting the improvement policy in the two cases described below.

1) Case of using the effluent of the existing facilities after additional treatment.

2) Case of using the reclaimed water after renovation including the secondary treatment facilities.

4-2 Reclamation of the water treated by the existing facilities

Detailed study is possible only after obtaining data on water quality. Accordingly, additional treatment to improve on the anticipated problems mentioned in the chapters before needs to be studied.

1) Removal of algae

As regards the method of removing algae, the most effective method seems to be coagulation and precipitation (or floatation). Direct sand filtration of the effluent from the stabilization pond is not practical because of severe clogging of the filter media but it is effective for removing SS contained in the water treated by coagulation and precipitation.

2) Reduction in salts concentration

There are two methods of reducing salts concentration dilution and desalination. The latter is not, however, a rational method as desalination takes place after condensation in the stabilization pond. If the salts concentration poses a problem, the water should be diluted by mixing it with that of a lower concentration before use; the possibility should be ascertained on the basis of actual data.

3) Removal of heavy metals

The method of removal should be studied according to the kind and the concentration of the heavy metal contained in the reclaimed water.

4) Sterilization

Chlorine consumption may be reduced by removing organic SS, making it easier to maintain the concentration of remaining chlorine over the required level, stabilizing the sterilization effect. Accordingly, sterilization by chlorine after treatment by coagulation and precipitation produces the sterilization effect with the existing facilities; it is also said to be effective for removing viruses and parasite eggs.

When there is a possibility of the reclaimed water being continuously used as drinking water by man and cattle, the toxic nature of organic chlorides caused by chlorination should be studied. As for a countermeasure, remaining organic materials may be removed as much as possible by adsorption with activated carbon, or the sterilization agent may be changed from chlorine to ozone. However, their effects should be carefully studied.

4-3 Use of the reclaimed water after renovation including the secondary treatment facilities

Assuming that the treated water will be reused, the process of the secondary treatment may be selected by taking account of the following factors:

1) High and stable treatment efficiency;

2) Minimum water evaporation during the treatment process (low salts concentration rate).

In the light of these factors, though technical expertise will be required for operational control the conventional activated sludge process seems to be the most suitable one for the following reasons:

1) High removal efficiency for BOD, COD and SS.

2) The treatment efficiency is not affected so much by environmental conditions.

3) Removal of heavy metals may be expected to some extent.

4) High removal efficiency for coliform bacteria, viruses, parasite eggs, etc.[3)]

5) Water evaporation may be kept at a low level.

In other words:

1) Loss of water due to evaporation during the treatment may be minimized with a low rate of salts concentration.

2) Good quality of the treated water enabling sophisticated treatment according to the purpose.

Other points to be considered are similar to those under 4-2; they should be studied on the basis of detailed data on the site conditions.

REFERENCE

1) "Water Quality Criteria" SWPCB, Calif, U.S.A. (1952)

2) R. D. NAUFELD and E. R. HERMAN "Heavy metal uptake by aclimated activated sludge" Journ. of W. P. C. F. 47, 310 (1975)

3) R. SUDO "HAISUISHORI no SEIBUTSUGAKU (Biology of waste water treatment)" SANGYO YOSUI CHOSAKAI (1977)

II. PROBLEMS IN THE AL-HASSA IRRIGATION AND DRAINAGE PROJECT

The Survey Team on the Reuse of Waste Water conducted a field survey at the Al-Hassa area on June 18-21, 1980. This is a report of a few problems relating to irrigation and drainage, which the Survey Team became aware of during the survey.

1. Reuse of the Water in the Drainage

The HIDA is currently conducting a cultivation test on the possibility of reusing the water in the drainage at the 24 ha experimental field.

In this test the field of 24 ha is divided into three blocks of 8 ha each, and in the each block vegetables, wheat and grass are cultivated in a different way. The first block is irrigated with drainage water only, the second block with drainage water and spring water mixed at various ratios and the third block with spring water only. The test is intended to ascertain the possibility of reusing drainage water after diluting it by comparing the three blocks in respect to the growth and salt concentration.

Though the results of the test will not be available until next summer, it is a valuable experiment if it can be concluded that the water may be reused by diluting it at an appropriate ratio, there will be a possibility of obtaining a new source of irrigation water by means of mixing the treated sewage of Hofuf described in 1 with drainage water.

However, successful reuse of the water depends, first of all, on whether the salinity, the major obstacle to irrigation in dry areas, can be curbed; it also depends on whether the method and facilities can be established to remove harmful heavy metals, excessive phosphorus and nitrogen etc.

2. Effective Use of Water Discharged into the Drainage in Winter

The total irrigated area of 8,000 ha in the Al-Hassa area requires 9.5 m^3/sec of water at a summer peak period; but the winter requirement is extremely small. On the other hand, the flow from the springs is estimated to be almost constant throughout the year. Accordingly, it is possible to irrigate part of 4,000 ha in winter, located in lower reaches of the 8,000 ha. There still is a surplus in winter; thus part of the flow from the springs is directly discharged into the drainage without being used for irrigation. If this surplus can be kept at a suitable place to be used in summer, it may be possible to increase the area for summer crops from the current 8,000 ha.

However, because of severe natural conditions, storage is not as easy as is imagined in Japan. For instance, in the case of a simple surface reservoir, since rainfall can be hardly expected and it is subjected to extensive evaporation, there will be problems such as a reduction in water volume and deterioration in water quality due to a rise of salinity.

In summer, on the other hand, since the demand for irrigation water is extremely large, storage on a small scale is not expected to be sufficient to secure irrigation water to cover the entire growth period of crops. If the area to be irrigated is 1,000 ha, irrigation period 120 days and the required volume 10 mm/day on average, it is necessary to secure a net water volume of 12 million m^3. Even with the construction of facilities of such a structure as to minimize the loss due to evaporation, a reservoir of 12 million $m^3 \div 0.8 = 15$ million m^3 will be required by taking account of twenty percent conveyance loss. If the average depth is 5 m, the reservoir should have a total water surface of 300 ha.

The above conditions reduce the technical possibility of storage. However, in the Kingdom of Saudi Arabia where water is scarce, it seems worthwhile to study the storage possibility of water in detail to grope for a feasible project.

3. Treatment of Weeds along the Drainage

The unlined slope of the main drainage with a total extension of about 60 km is covered with weeds reaching 2 m high, which the

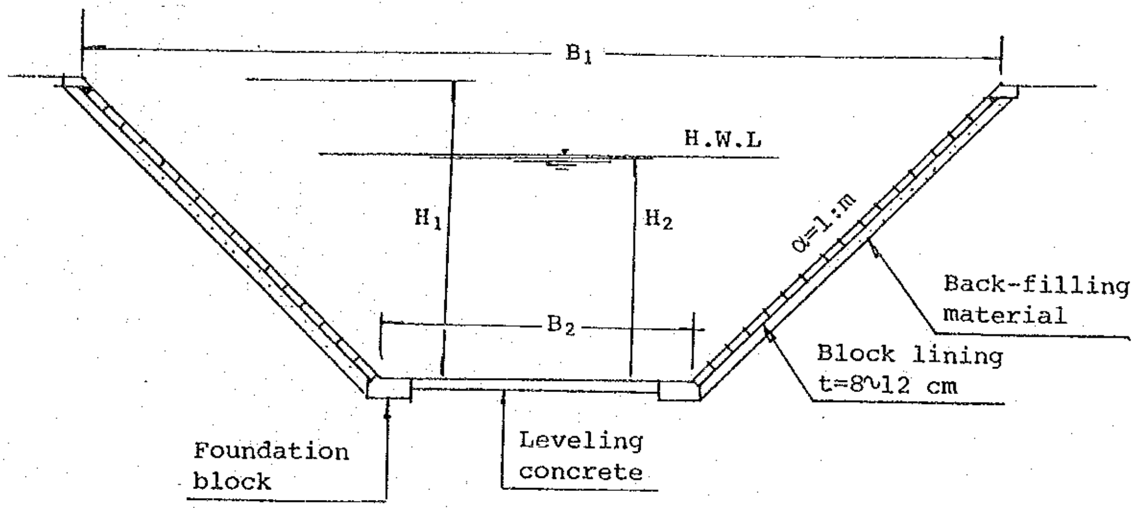
HIDA finds it extremely difficult to cope with. As regards the use of weeding chemicals, since the local residents have been using the water for household purposes such as drinking and it may also lead to the pollution of groundwater and of the Arabian Gulf, the HIDA have mainly been using mowers; but this requires an extremely large amount of labour.

A countermeasure is the lining of the slope and the HIDA are studying the possibility of using rubber sheets. It may also be worthwhile to study block lining which is often used in Japan. Block lining may be outlined as shown in the attached plan. Since the drainage has the function of catching leaching water, the B-type with the bottom unlined may suit the area concerned. Costs of the B-type in Japan (including the costs of materials) are about 5,500 yen, or RS80 per m^2.

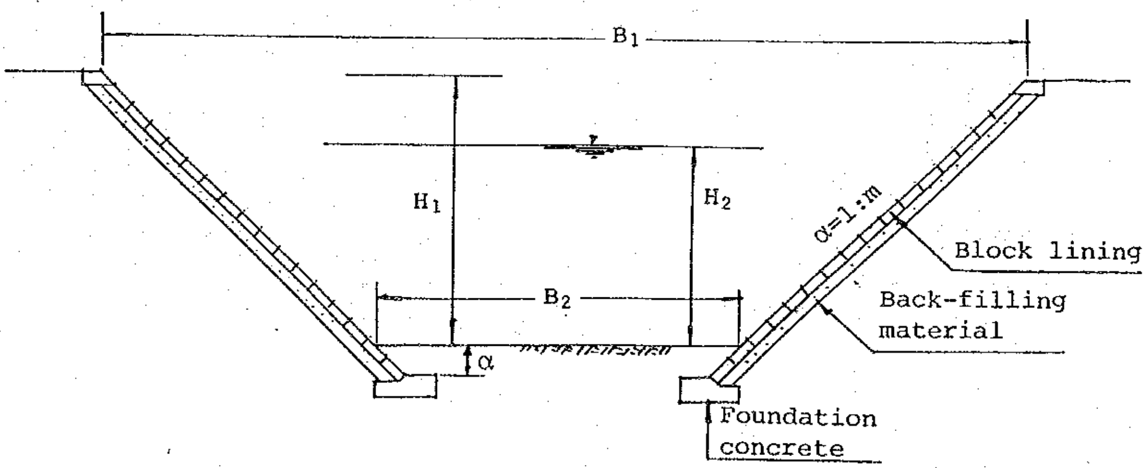
Further, since it seems possible to obtain asphalt materials at a low cost in the Kingdom of Saudi Arabia, the possibility of asphalt covering should also be studied.

STANDARD PLAN OF THE DRAIN CHANNEL

A Type



B Type



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