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Improvement of water quality in Nakhon Ratchasima (Thailand)
Technical Proposal

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Kitakyushu City Environment Preservation Association[1]

Keiichi WATANABE, Naomichi SUGIMOTO

[1] 97-3 Nishiminato-machi, Kokurakita-ku, Kitakyushu City 803-0801, JAPAN, Fax: +81-93-582-7850

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The following recommendations were developed with regard to the improvement of water quality in open drains and Lam Ta Kong River, based on the outcome of the field survey[2] to Nakhon Ratchasima[3] (Thailand).

I. Category specific measures

1. Improvement of open drains
    1) Discouraging illegal disposal of garbage
    2) Regular removal of weeds from open drains
    3) Improvement of surrounding area of open drains

    Decreases in wastewater discharge (measures to decrease BOD density in wastewater)
    1) Decrease in domestic wastewater or effective use
    2) Decrease of BOD density in wastewater
    3) Improvement of wastewater from septic tanks
2. Improvement of simple water treatment plants
    1) Current situation
    2) Recommendations for improvement
        (1) Prerequisite conditions
        (2) Plane filter method
        (3) Points of attention

II. Overall measures

1. Comprehensive wastewater treatment facility for canal (oxidation pond)
2. Future measures for improvement of water quality in canal
    1) Case specific measures
    2) Wastewater regulations

Reference 1: Wastewater treatment plant with plane filter
Reference 2: Field Survey at Canal in Nakhon Ratchasima

Attachment1: Improvement of wastewater outflow from septic tanks (Trickling filter)
Attachment 2: Trickling filter diagrams

[2] 24 April to 4 May 2002 in Nakhon Ratchasima/Korat and Nonthaburi (Thailand)
[3] Nakhon Ratchasima is popularly known as “Korat”.

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Improvement of water quality in Nakhon Ratchasima

I. Category specific measures

1. Improvement of open drains and wastewater controls (measures to decrease BOD density in wastewater)

   During the field visit to the target area, thick weeds were observed in open drains, as well as illegally disposed garbage. Residents do not conduct any regular activities to clean the open drains. To address this issue, communities should carry out the following measures, with guidance from the local government. The initiative of residents is necessary to conduct and continue activities. Through the implementation of the following items, the density of BOD in the wastewater should decrease slightly.

   1) Illegal disposal of garbage

      Placement of dust-bins, etc., and conduct of education activities.

   2) Regular removal of weeds from open drains

   3) Improvement of surrounding area of open drains

      By planting flowers and trees, residents will take more pride in and become more attached to their communities. This aspect is important in increasing community awareness.

It is essential for residents to be aware of the direct effect of individual actions on the surrounding environment to decrease wastewater. Additionally, it is necessary to provide guidance regarding changes in lifestyles, as follows.

1) Decrease in domestic wastewater or effective use

   Through the effective use of wastewater, the amount of wastewater discharge can be decreased. Thought should be given to decreasing the amount of water used or effective use of wastewater.

2) Decrease of BOD density in wastewater

   Foam or bubbles were not observed in the open drains; therefore, it can be inferred that plant and animal detergents and soaps are used, rather than synthetic detergents and soaps. As these types of detergents and soaps are a source of BOD, information and guidance should be provided to residents to ensure that these types are not used.

Future issues are as follows.

3) Improvement of wastewater from septic tanks

The current method to treat wastewater in Korat is natural purification through underground permeation using microbes (bacteria). However, natural purification is limited in concentrated areas, such as the city center. If wastewater is left untreated, underground springs or wells can become contaminated and may flow to the canal. The current measurement data (at points K5~K8) corroborates the idea that the water quality of the downstream area is severe.

If the outflow of water from septic tanks is to be improved, wastewater effluent must be controlled. To accomplish this, an explanation of a trickling filter treatment method is attached[4].

2. Improvement of simple wastewater treatment plant

1) Current situation

Using local technology, simple wastewater treatment plants are constructed and anaerobic treatment methods are applied. Based on data received, the BOD levels in wastewater inflow are approximately 190mg/ℓ; the BOD levels of treated water (outflow) are approximately 70mg/ℓ (regular time periods). These figures are impressive however further reduction of BOD cannot be expected unless additional actions are taken.

Garbage was observed in the open collection tanks at the entrance of the wastewater treatment plants. During discussions with the Municipality staff, it was understood that continuous clean-up activities are not conducted. Additionally, while the height of the open collection tanks is not a problem, the width is not sufficient. As a result, the open collection tanks are unable to handle a normal inflow of water to the wastewater treatment plant.

> (Notes): Most wastewater treatment plants are not designed to treat atypical amounts of water (heavy rains, etc.). In such cases, if the water level rises over the height of the open collection tanks, untreated water can bypass the treatment plant and flow directly to the river. Because wastewater from rainfall is diluted, this type of untreated water is not a cause for concern.

2) Recommendations for improvement

(1) Recommendations are based on the following conditions:

[4] Attachment 1

① Use of local technology for simple wastewater treatment plant

② Treatment of wastewater without using electric energy (ventilators, pumps, etc.)

③ Construction of structures using local technology and materials that can be procured onsite.

④ Secure sufficient space for construction of plants, with little difference in ground levels for untreated wastewater inflow and outflow of treated water.

⑤ There is little expectation that further improvements can be made using the current anaerobic treatment. Therefore, adoption of an aerobic treatment method is recommended, as this method has a greater capacity to purify wastewater.

⑥ The simple wastewater treatment plant continues to reduce BOD density at the same approximate level as current data (BOD=70mg/ℓ).

⑦ Regular clean up of mud and sludge inside plants and inspection of facilities is not required; it can be conducted as necessary (low maintenance).

An appropriate wastewater treatment plant that meets the above conditions is a **plane filter**[5]. A plane filter can be connected to the back-end of storage tanks that use anaerobic treatment methods (such as septic tanks). Plane filters treat the natural flow of wastewater from these tanks using aerobic treatment methods. When there is little difference in the inflow and outflow ground levels, this type of method is appropriate. Plane filters are square concrete tanks, with flat bases, inside which simple partitions are constructed to slow down water flow. Aerobic microorganisms grow in the base of the filter. For the respiration of these aerobic microorganisms, oxygen (air) is necessary; therefore, "exhaust pipes" (ventilation pipes) must be constructed. In order to have natural ventilation from the wind, it is essential to have additional entrances for air (air intake holes or pipes) in addition to the exhaust pipe. With this type of aerobic treatment method, the BOD reduction rate has a limit of 30-40%, depending on conditions. Surplus mud in the filter will be expelled when the water flow is heavy therefore it is not necessary to clean the inside of the filter.

(2) Plane filter structure

① The design for the plane filter is based on the current anaerobic treatment method.

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[5] Reference 1: (a) Minimum area for plane filter for each community (Table 1), (b) Wastewater treatment plant with plane filter (Diagrams 1-4)

The height of the open collection tanks at the entrance of the current wastewater treatment plants is appropriate, however, the width should be enlarged to manage the regular inflow of wastewater.

② The minimum base area for the plane filter structure is calculated by the following formula.

Area (m2) ≧ 2.0 + 0.1 (n - 5)

n =5 X (number of households in community)

n: Number of users to design for

(Notes): The treatment capacity of treatment plants is shown in Table 1 (Reference 1) as the number of users to design for (n = 5 X (number of households in community)). Here, the number of users to design for does not mean the actual number of persons who are using the plants. Because of large fluctuations in the number of people using the plants, the capacity is calculated by a standard.

Regardless of the shape and quality of materials, the use of reinforced concrete is recommended. Depending on the shape of the filter, supports constructed of reinforced concrete should be placed in appropriate sections to avoid the collapse of the filter covering. The concrete slabs should be 5cm thick.

The appropriate height of the inside section should be 0.5 to 1 meter. If it is not high enough, the air will not pass through the structure completely.

③ Construction of winding channels inside the filter using cement partitions (width: 20-30cm, height: 5cm)

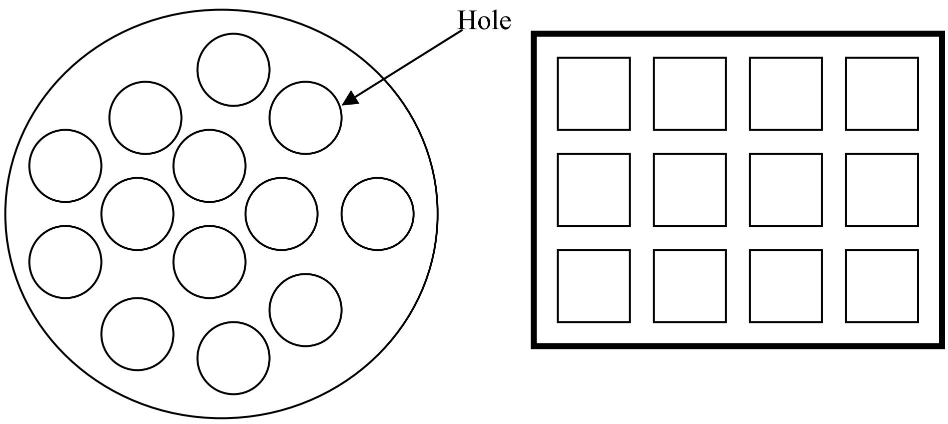
In order to treat the inflow of wastewater, contact materials are placed at the base of these channels to retard the flow of water. A sedimentation pit is constructed at the end of the channels in order to settle the outflow of sludge and discharge effluent.

④ The size for ventilation pipes (“exhaust pipe” and “entrance of air”) is calculated as follows:

Exhaust pipe, Entrance of air (m2) ≧ calculated plane filter area (m2) X 0.1/23

There is no limitation on the height of the exhaust pipe. Depending on site conditions, the pipe should be high enough so that wind is able to pass. The exhaust pipe should be constructed at the entrance to the plane filter (inflow entrance). Polyvinyl resin pipes can be used. An umbrella can also be attached at the top of the exhaust pipe to prevent rain and waste from entering the filter.

The “entrance of air” should be constructed at the end of the filter (outflow of treated water). If air can easily flow into the filter tank, there are no restrictions on the shape or quality of materials. For example, a round or square concrete covering containing a number of openings can be used. For effective ventilation, the entrance of air should be constructed at opposite ends from the exhaust pipe.



⑤ In order to protect against backflow, there should be a few centimeters difference at inflow and outflow points (declining slope).

(3) Points of attention

1) The efficiency of a plane filter is determined by the slow and steady flow of water and the lack of stagnation. In cases where the area for the filter base is not flat, the area available for water flow will decrease and can result in a widespread reduction in wastewater purification functions.
2) Because the oxidation rate of plane filters is not high, it cannot have an effect on wastewater with high BOD density. Consequently, if the BOD levels in wastewater can be maintained below the current data (BOD=70mg/ℓ),

purification of the wastewater is possible.

3) Oxygen must be regularly provided to the aerobic microorganisms in the plane filter. Increases in water levels, etc., can drown the aerobic microorganisms if they sink into the water. To avoid this, plane filters should be constructed above the maximum water level of the canal in heavy rainfall periods.
4) The capacity of the sedimentation pit is the same as the existing open collection tanks.

II. Overall measures[6]

1. Wastewater treatment (oxidation pond)

   The oxidation pond that is now in operation is an appropriate method for wastewater treatment, because of low costs and continuous maintenance. However, BOD reduction rates are limited to approximately 50%. To further purify the water, a different method using aeration should be adopted. By increasing the concentration of dissolved oxygen in the pond, the purification capacity may increase. The following methods are proposed:

   1) Placing greenery such as algae in one oxidation pond to carry out photosynthesis
   2) Agitation using wind and sunlight (wind and solar power)

2. Future methods for improvement of water quality in canal

   1) Case specific measures

      Korat places a little too much emphasis on natural purification. Programs to change this way of thinking (education, guidance, etc.) are necessary. Additional case specific measures are proposed below.

      (1) Construction of individual wastewater treatment plants for wastewater that directly flows to the canal

      Purification of wastewater adopting either the plane filter or trickling filter method; there is no use of electric energy.

      (2) Increase of dissolved oxygen concentration in canal

      The elimination or dredging of mud/sludge (which is anaerobic) is thought to have the most effect on increasing the concentration of dissolved oxygen.

      (3) Maintenance of the riverside environment

[6] For more information, see Reference 2: Field survey at Canal in Nakhon Ratchasima

Removing weeds and collecting garbage along the riverside through public and private collaboration will increase the awareness of residents and improve the environment of the riverside.

If the riverside environment is improved through these activities, the canal may be used by businesses such as floating markets and as a means of transportation, as well as tourism.

2) Wastewater regulations

There is an issue of whether the current wastewater countermeasures and wastewater treatment plants (oxidation ponds) will be able to address future population increases. Wastewater regulations should at least be implemented through province or city ordinances for large-scale businesses that discharge wastewater in the future.

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Reference 2: Field Survey at Canal in Nakhon Ratchasima

From the two-day field survey at the canal in Nakhon Ratchasima, the following evaluations and recommendations were developed regarding water quality based on observations, data or from previous experience.

1) Geography: The water in the canal flows slowly from west to east. Most of the population is located in the eastern area (city center). Because the amount of polluted water is large, we can conclude that the water quality is worsening, based on the current data (K5~K8).
2) There is plankton in the canal. Oxygen is given off during the day during photosynthesis, which should increase the concentration of DO on the surface of the water. However, following measurements of surface and inner points of the water in the canal, it was concluded that there was less than 1mg/ℓ of DO, even though it had just rained. The on-site DO measurement data is almost the same as the data we received from Korat.
3) Concentrations of nitrogen and phosphates are too high in the canals. The situation is extremely severe downstream (in the city area); the bottom of the canal shows anaerobic tendencies and it seems that there is methane fermentation. Water pollution may occur through septic tanks (human waste) and household wastewater, as well as through agricultural wastewater in areas where there is little or no sewage treatment systems. In considering these issues, it can be concluded that water pollution is becoming more severe.

Wastewater that contains phosphates:

① It is difficult to think that it would be generated by household wastewater (baths, laundry, kitchen).
Previously in Japan, phosphate chemical compounds were added to synthetic detergent however, because no foam or bubbles were observed in the canal in Korat, we believe that the type of detergents used area plant and animal detergents, not synthetic detergents. Household wastewater would not be the cause of phosphate emissions; it would be the cause of BOD.

② Wastewater from septic tanks also contains phosphates.

③ Agricultural wastewater
We observed the agricultural areas of Korat however we did not feel that the soil contained much organic matter. Municipality staff provided information that composting activities were being conducted. However, based on observations, we surmised that chemical fertilizers (nitrogen, phosphates) are mainly being used, not organic fertilizer. If this is the case, the nitrogen and phosphates from the chemical fertilizers could be a cause for the decline in water quality.

Phosphates discharged from agricultural wastewater and the added phosphates from septic tanks, as well as anaerobic fermentation at the bottom of the canal, could increase phosphate levels in the river. Phosphate emissions from human waste in the city area are also high.

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Attachment 1: Improvement of wastewater outflow from septic tanks
(Introduction of trickling filter)

Plane filters can only be used in cases where there are no differences in water levels for inflow of wastewater and outflow (treated) water levels. When there is a difference in these levels, a **trickling filter method**[7] is appropriate. The trickling filter can reduce BOD rates by 40-50% depending on conditions. Compared to the plane filter, it is highly efficient with good oxidation rates. It should be constructed at the backend of septic tanks otherwise solids will block the filter.

The current method to treat wastewater in Korat is natural purification through underground permeation using microbes (bacteria). However, natural purification is limited in concentrated areas, such as the city center. If wastewater is left untreated, underground springs or wells can become contaminated and may flow to the canal. The current measurement data (at points K5~K8) corroborates the idea that the water quality of the downstream area is severe. Improving the quality of water outflow from septic tanks can be related to the overall improvement of the water quality of the canal. Recommendations to construct a trickling filter to purify the water without electric energy are as follows.

(1) Prerequisite conditions

① Use of local technology for simple wastewater treatment plant
② Treatment of wastewater without using electric energy (ventilators, pumps, etc.)
③ Construction of structures using local technology and materials that can be procured onsite.
④ Securing sufficient space for construction, and approximately 2 meters difference between inflow water levels and outflow (treated) water levels.
⑤ Aerobic treatment of outflow of water.
⑥ Regular clean up of mud and sludge inside plants and inspection of facilities is not required; it can be conducted as necessary (low maintenance).

An appropriate wastewater treatment plant that meets the above conditions is a **trickling filter**. This type of filter can be connected to the back-end of storage tanks that use anaerobic treatment methods (such as septic tanks). Trickling filters treat the natural flow of wastewater from these tanks using aerobic treatment methods. This method is appropriate when there is more than a 2-meter difference between the inflow water level and outflow (treated) water level. Trickling filters are square concrete tanks and contain crushed stones. Wastewater overflows from the V-notches in the weir and trickles over the surface of the stones. When the water

[7] Attachment 2: Trickling filter diagrams

falls to the bottom, it is purified.

(2) Designs/plans/specifications are as follows.

① The design for the trickling filter is based on current methods.

② The minimum effective capacity of the trickling filter is calculated as follows
Effective capacity (m3) ≧ 0.50 + 0.05 X n
n= 5 X (number of residences in community)

The main tank of the trickling filter should be constructed of reinforced concrete. Crushed stones (5-7.5cm) can be used as the solid media in the filter. In Japan, granite is used because it has an uneven surface. A screen should be placed 10cm above the bottom of the tank so that substances will be trapped and filter media does not fall. Effluent from septic tanks flows into the main weir and through the trickling weir.

③ The size of the exhaust pipe should be more than 100mm in diameter and more than 3 meters high. It should be placed at the trickling filter inflow entrance. Polyvinyl resin pipes can be used. An umbrella can also be attached at the top of the exhaust pipe to prevent rain and waste from entering the filter.
The "entrance of air" should be constructed at the end of the filter (outflow of treated water). If air can easily flow into the filter tank, there are no restrictions on the shape or quality of materials. For example, a round or square concrete covering containing a number of openings can be used.

④ The effluent pipe should be more than 100mm in diameter.

(3) Application

The above method has been limited to septic tanks however it can also be used for household wastewater. In this case, a putrefaction chamber should be constructed and connected to the trickling filter. The amount of wastewater from household wastewater is larger compared to septic tanks and the numerical value of reduction rates of BOD is comparatively low. The trickling filter can be used to purify household wastewater that directly flows to the canal.

(4) Points of attention

1) The purification capacity of the trickling filter can be determined by observing how uniformly wastewater flows from the V-notches in the weir and how the water

trickles on the stone surface. V-notches finely regulate the flow of water.

2) The rate of BOD reduction of trickling filters is higher than plane filters. The reason for this is that the surface area of trickling filters is larger (crushed stone layer area/crushed stone layer capacity=80-120 m2/m3).
3) In the trickling filter, air comes from the “entrance of air” and flows along the bottom of the filter, through the crushed stone layer, and out the exhaust pipe at the upper section of the filter. Consequently, if the wastewater outflow exit at the bottom of the filter becomes blocked, air cannot pass through and the aerobic microorganisms die. In order to avoid this, it is necessary to monitor the water quality outflow at the exit at the bottom of the filter.