



# **Current Situation and Considerations of Domestic Wastewater Treatment Systems for Big Cities in Indonesia (Case Study: Surabaya and Bandung)**

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## **ABSTRACT**

Big cities in developing countries often have problems managing their domestic wastewater. Indonesia as the fourth most-populated country in the world also faces many challenges regarding domestic wastewater management. Surabaya and Bandung are the second and third most-populated city in Indonesia, with a population of 2,765,908 and 2,393,633 respectively. As demand for urban domestic wastewater treatment systems increases, the decentralized wastewater treatment system is considered as an alternative which has big potential for implementation.

This paper provides a brief review of urban domestic wastewater treatment approaches in Indonesia, especially in Surabaya and Bandung, and their potential of application in cities with similar characteristics. The alternative technologies reviewed in this paper include locally developed and accepted technology (such as septic tanks) and some new promising concepts which have not yet been well established in Indonesia (such as DEWATS or ecosan systems). Studies showed that despite high hygienic risk potential and low environmental performance, septic tanks were still most preferred by the community. It is crucial to ensure social, financial and technical sustainability of the alternative approaches, so that the option chosen to be applied can really be sustainable.

*Keywords:* Domestic Wastewater; Septic Tanks; Decentralized Wastewater Treatment Systems (DEWATS); Ecological Sanitation (Ecosan)

## **1. INTRODUCTION**

Many cities in developing countries have problems in managing their domestic wastewater, especially in big and densely populated cities. Indonesia as the fourth most-populated country in the world (238 million populations in 2010) also faces many challenges regarding domestic wastewater management, which includes blackwater (toi-

let wastewater) and greywater (wastewater from bathing, washing and other non-toilet activities) management.

Only 12 cities (Jakarta, Tangerang, Bandung, Cirebon, Solo, Yogyakarta, Banjarmasin, Samarinda, Mataram, Medan, Parapat, Denpasar) in Indonesia have some kind of sewerage systems, which serve around 2.13% of the national population (Mungkasa and Wahyudi, 2010). This level of coverage is among the lowest in Asia. Environmental deterioration in rivers, lakes and other public water bodies in Indonesia, has been increasing

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considerably over the past decades. The main sources of the water pollution are domestic wastewater (around 60%) and industrial wastewater (around 40%) discharged into the water bodies.

Most of Indonesia's population growth has been centred in urban areas. In 1970, approximately 15% of Indonesia's population was urban dwellers and this has increased to around 44% in 2010. This urban transition is occurring more rapidly on Java Island where almost 50% of the population lives in urban areas (DESA, 2010). Such a massive number of people living in cities will need adequate infrastructure and services, such as water supply, housing, and sanitation facilities. Because public investments from the Government of Indonesia has been lacking, most of the domestic wastewater infrastructure has been made by the households themselves. The use of waterborne toilets is very common and well established in Indonesia; most of them are pour-flush squatting toilets. However, because law enforcement from local governments are very weak; many households do not dispose of their wastewater safely. Many toilets discharge into a *tangki septik* (septic tank), which is often unsealed and does not have a soakpit to further treat the effluent from the septic tank. Therefore, in most cases the wastewater is discharged untreated or partially treated into open drains, canals, rivers and ponds. Fecal contamination of urban ground water resources is widespread, but many people remain reliant on wells for their drinking water. This has created severe environmental pollution (i.e. eutrophication) and high-incidence of water- and sanitation-related diseases, such as diarrhea and typhoid.

This paper will give a review of some approaches in domestic wastewater treatment systems that have been implemented in Surabaya and Bandung, as well as their potential of application in cities with similar characteristics.

## 2. DOMESTIC WASTEWATER TREATMENT SYSTEMS IN SURABAYA

Surabaya City is the capital of East Java Province in Indonesia. It is the second largest city in Indonesia, which is inhabited by around 2,765,908 people (Census 2010) and has an area of 374,78 km<sup>2</sup>. The average population density is 7,380 person/km<sup>2</sup>. Its elevation is 5 m above sea level. Surabaya is known as an industrial, commercial and maritime center, and holds a very important part for the eastern part of Indonesia. Until now, there is no existing sewerage system and centralized wastewater treatment for the whole population. Main source water for the municipal water supply comes from the Surabaya river, which has been contaminated by domestic and industrial wastewater discharged by the communities and industries located upstream as well as along the river.

As in other cities in Indonesia, households in Surabaya also separate blackwater from greywater. The blackwater usually goes to the septic tanks or nearby water body and the greywater goes untreated to drainage channel or nearby water body. According to the City's Health Department, from 799,336 households in 2008, 72.58% have private toilet at home and 99.86% of them fulfill the department's requirements. 70.34% of these toilets are equipped with septic tanks, but only 69.50% of these septic tanks fulfill the requirements (CSHD, 2008). This practice is risky and not suitable for high-density and low-income urban area (slums) because of limited financial capability and available space. Thus, in these slum areas the problem with domestic wastewater management as well as the risks to the environment (pollution) and community's health (disease spread) is much higher. Thus, other alternative for these areas is needed, such as building communal/public toilets equipped with simple on-site wastewater

treatment facilities.

There has been a plan to build a centralized wastewater treatment plant and sewerage system for Surabaya city. The Surabaya Sewerage and Sanitation Development Programme (Surabaya SSDP) is a sanitation master plan prepared in 1997 to serve projected inhabitants of 3.3 million in 2020. The master plan consisted of technical, economical, financial, social, institutional and environmental aspects. It was formulated by setting criteria that prioritized to area having high population density, low income family, low water use, lack of sanitation facility, greywater disposal to open drains, and high incidence of diarrhea (Mangkoedihardjo, 2010). Until now, the master plan has not been implemented. Presently, population number has increased to almost 3 million and human settlements have expanded to the whole city that produces more wastewater loads to land and surface waters. Thus, the implementation of this master plan should be re-considered from the beginning because there are a lot of reasons, both technical and non-technical, that would make this centralized wastewater treatment concept difficult and uneconomical to be implemented in Surabaya.

Other alternative for domestic wastewater treatment that has been gaining more attention at the provincial and national level is the decentralized wastewater treatment systems (DEWATS), which was implemented through the *Sanimas* (*Sanitasi oleh Masyarakat* or Sanitation by Community) program, a Community-based Sanitation (CBS) program. All of the options are modular for community sizes of 100 to 200 households. Communities are offered three choices for sanitation improvement (WSP, 2009):

- (i) Shared (communal) septic tanks for groups of four to five households. In this model, the household has to build its own toilet and connect it to the septic tank;
- (ii) Enhanced communal bathing, washing and

toilet block facilities (locally known as *MCK - mandi, cuci, kakus*) including bio-gas capture and reuse; or

- (iii) A shallow sewer leading to a communal sewage treatment facility (usually a baffled reactor). For this option the individual household provides its own toilet and connection to the sewer.

There have been many *Sanimas* implemented projects throughout the country in collaboration with local governments and communities. *Sanimas* is an alternative option for local governments to improve sanitation for communities with low income in densely populated urban areas. It aims to fill the important gap between inappropriate or non-existent on-site sanitation and conventional/less affordable sewerage systems, and promote behavior changes towards sanitation. The selection of a technical option varies from location to location depending on available finances, physical constraints and the demand from the community. Ultimately, the community chooses its sanitation system. In 2003, 6 *Sanimas* projects were launched and, according to the Ministry of Public Works of Indonesia at the end of 2009, *Sanimas* coverage has grown significantly since, with 420 sites in 2009 (JSC, 2010). From all existing *Sanimas* projects in Indonesia (already implemented in 22 provinces), 32.59% projects are located in East Java province.

In Surabaya City alone, there are 5 locations implementing DEWATS concept but are not funded through the *Sanimas* program. These 5 sites are communal public toilets with wastewater treatment facility, known as MCK Plus++. These toilets are called MCK Plus++ because the public toilets have some added values/benefits, such as much better design and facilities provided, own wastewater treatment, and in some facilities which are equipped with anaerobic digester tank, biogas is also produced and can be used for cooking.

Since the first launching of Sanimas program in 2003 until 2009, there are 327 MCK Plus++ that have been built in 22 provinces in Indonesia (Mungkasa and Wahyudi, 2010). Thus 77.86% of the Sanimas projects implementation had opted for MCK Plus++ as their technology option. These MCK Plus++ have been highly accepted by the local community, thus it could be a very suitable model for other high-density low-income urban area, where most of the people who live there do not have their own private toilets.

Besides SSDP and DEWATS, there is another approach which is a sustainable option to manage domestic wastewater, that is the ecological sanitation (Ecosan). This alternative has also been considered and studied to be implemented in Indonesia. Ecosan treats human excreta as a resource and is based on three fundamental aspects: (1) rendering human excreta safe, (2) preventing pollution rather than attempting to control it after pollutions, and (3) using the safe products of sanitized human excreta for agricultural purposes ('sanitized-and-recycle') (Esrey and Gough et.al., 1998). Ecosan concept is based on the new paradigm that waste is not waste. It is a resource because it contains a lot of nutrients that should be given back to agriculture. Nutrients that are recovered from the blackwater (faeces and urine) and also the greywater could be used as fertilizer/soil conditioner. Some experiments have been done by the main author to study the effect of fertilizer/soil conditioner made from human faeces and urine, and so far it has showed good results. In general, the application of urine as fertilizer, also in combination with composted faeces, had a significant effect on the plants' growth. Urine and faeces were applied as fertilizer for some vegetable plants, such as tomato (*Lycopersicum esulentum Mill*) and field mustard (*Brassica rapa*), which showed better growth compared to plants which were given no fertilizer and the ones fertilized with NPK

(Prihandrijanti, 2006).

On the other side, the implementation of Ecosan in Indonesia, especially in big cities still faces many barriers, i.e. from socio-cultural and operational aspects. Based on a preliminary study on Ecosan implementation in Surabaya-Indonesia, the concept of Ecosan still has not been received well in Indonesia. When asked about willingness to accept a sanitation system, where people have to move or change place a little bit when they clean their body parts after defecating/ urinating (not directly over the closet) and whether they were willing to use a separating toilet with 2 holes, where the urine goes into the front hole and faeces into the back hole, 46.8% and 54.9% respectively accepted. Those who did not accept this thought that this was impractical, complicated and uncomfortable for them. Regarding dry sanitation, where people have to use ash/soil/sand/ sawdust to cover their faeces, only 8.9% accepted. The others do not accept this mostly because they thought that this was dirty and could make people sick, or impractical, complicated and uncomfortable for them. Many people also have not heard about the utilization of human faeces and urine as fertilizer (37.9% and 9.7% respectively). But when asked about their willingness to use fertilizer made from human excreta (urine and faeces altogether) if they were a farmer, 57% accepted because many people have heard of and use fertilizer made from animal waste and they thought as long as it is good then they can accept it (*Ibid.*).

### 3. DOMESTIC WASTEWATER TREATMENT SYSTEMS IN BANDUNG

Bandung City is the capital of West Java Province in Indonesia. It is the third most populous city in Indonesia with a population around 2,329,928 inhabitants (Census 2010) and an area of 167,67 km<sup>2</sup>. The average pop-

ulation density is 13,896 person/km<sup>2</sup>. Its elevation is 798 m above sea level. In 2006 and 2008, the Indonesian government chose Bandung as the dirtiest metropolitan city. Since then, many efforts for upgrading environmental condition have already been done, but most of them were only short time movement and especially sanitation sector is still a big problem. Most of the population has no connection with centralized water supply and wastewater treatment plant as well. Nowadays, 80% of the water supply comes from the river. Thus, with most of the domestic wastewater flowing into the river one can expect that the river had been contaminated. In the last ten years, supply from the river to the municipal water treatment plant continues to decline from 25 to 15 million cubic meters because of many reasons.

Bandung City is one of 12 cities in Indonesia that already have a centralized wastewater treatment system (with limited service against the total population). The plant, which is called IPAL Bojongsoang, has a capacity of 89,000 m<sup>3</sup>/day and cover treatment for Eastern Part of the city. Only around 35% of the population are connected to the plant in Bojongsoang. In regard to area also about 30% of Bandung is covered with the sewer (ESP-USAID, 2006). Nowadays, the operational is not effective because existing work capacity is only 40,000 m<sup>3</sup>/day. The plant is also suffering from people living around the area, who take water directly from the open sewer channel and ponds for irrigation. In addition, septage collector trucks often bring not only domestic wastewater but also non-domestic wastewater coming from small/home industries. The wastewater flows by gravity. It is raised at some pump stations to a higher level from where it flows again by gravity.

In some areas open channel are used to transport wastewater to Wastewater Treatment Plant. During the dry season farmers some-

times use this wastewater to irrigate their fields. Some sewer pipes come from the Dutch period, which is then expanded. Since 1983-1992 there was a Bandung Urban Development Project (BUDP), which has successfully built 468 km sewerage system with pipe diameter varied between 150-2100 mm. Previously the wastewater that come from Eastern and Western Region was planned to be treated in two separate WWTPs, but in western region (wastewater generation around 23,000 m<sup>3</sup>/day), there is no more WWTP exists. Therefore all wastewater from the sewer in the western region is discharged directly to the Citepus and Cikapundung River (Amarto, 2008).

The limited coverage of the centralized wastewater treatment has forced housing complexes to treat its blackwater with on-site system (septic tank) and discharge the greywater through open channel straight into the rivers. As well as other cities in Indonesia, the most common sanitation facility in Bandung is septic tank, which accounts for 83% of the population. For low-income group, a communal septic tank is the main sanitation facility. Use of individual septic tank increases with rising income and also supported by the availability of bigger space that the family can procure with rising income. However, for all economic classes, there is a tendency to discharge the blackwater directly into the water body if the house is located close to it; even though with higher economic class, the tendency becomes lower. It is also supported by another survey in 2009, which was conducted in specific areas (kelurahan Sadang Serang) where 24% of the respondents discharge blackwater to the river and 7% to gutter/drainage channel, while 51% respondents discharge to the city sewerage system available (Paramita and Soewondo, 2009). For this area, using sewerage system is the best option because they have limited area to build septic tank. About 75% of the respondents separate

greywater from blackwater. The untreated greywater are mostly discharged into the drainage channel (58%). Another significant greywater disposal route is directly to the water body or river (around 30%), and 12% respondents discharge their greywater to septic tanks (Firdayati, et.al, 2010).

#### **4. POTENTIAL DOMESTIC WASTEWATER TREATMENT SYSTEMS FOR BIG CITIES**

From the above description it can be seen that on-site treatment system (septic tank) is still the most widely accepted method for domestic wastewater treatment. However, this method does not treat greywater. Thus, another treatment system is still needed to accompany household septic tanks and more efforts should be given to ensure that the on-site (septic tank) systems function well according to the health and safety requirements without polluting the environment. While centralized wastewater treatment system can treat both black- and greywater, its implementation in already densely-built city like Surabaya will face many problems, technically and non-technically. For cities like Bandung which already had this centralized wastewater treatment system since a long time ago, it might be easier to be implemented, but great effort still needs to be given to ensure that the system functions well. Thus, an optimized combination of centralized and decentralized wastewater treatment systems could be a good alternative for some cities.

One approach that has great potential to be sustainable in big cities is the decentralized wastewater treatment systems (DEWATS). This system consists of several smaller wastewater treatment units serving individual houses, clusters of houses or small communities, or communal toilets system such as the MCK plus++ which is a combination of conventional but improved MCK system and

DEWATS. MCK plus++ is very suitable for use in densely populated urban areas that have poor access to toilets and washing facilities. Non-centralized systems are more flexible and can adapt easily to the local conditions of the urban area as well as grow with the community as its population increases (Schertenlieb and Heinss, 2000). This has been proven well by the implementation of DEWATS and Sanimas projects throughout Indonesia.

Conventional forms of wastewater management and sanitation are increasingly critiqued for ecological and economic reasons. It is not just because of the rising cost of building, operating and maintaining a wastewater treatment plant, but also the fact that they misuse drinking water as a transport vehicle and contribute toward the contamination of water cycles with sewage. This causes health hazards and damage to the environment. Moreover, they lead to other problems. They impair soil fertility by preventing the valuable nutrients and trace elements contained in human excrements from being recycled back into agriculture. Even when sewage sludge is put to agricultural use, only a small fraction of the nutrients are actually reintroduced into the bioactive topsoil. Most of the nutrients are either destroyed (e.g. by the nitrogen elimination process) or find their way into the water regime, where they pollute the environment. Frequently, the use of sewage sludge from centralized wastewater management systems must also be restricted due to the high concentration of heavy metals and other harmful substances, often as a result of intermixing household sewage with industrial wastewater and surface runoff from contaminated streets (GTZ, 2002). From this point of view, Ecosan could be a very good alternative.

Ecosan is a sustainable, ecological and economical concept. However, it has some barriers for implementation in urban areas. One of the problems that could come up from the implementation of Ecosan (source control)

in household level in Indonesia is the management and further treatment of urine, which has to be stored in diluted form, because the Indonesian community are still not used to dry sanitation, including in urinating. Direct application in own yard is also often not possible because it is very difficult and very expensive to have a yard/garden in low-income urban area, which is usually very densely populated. Compost application might not be so difficult, because its volume/generation is not so high. Therefore, further research and study is very important in order to find better solution to facilitate storage, transport and reuse of urine in low-income urban areas. Approaches to encourage the acceptance of dry sanitation might also be very advantageous. Ecosan systems can actually be well-implemented in low-income urban area, because it has many benefits and does not need sophisticated technology. The system can be operated and maintained easily, even by low-educated people. However, special approaches and high engagement are needed in order to make this concept really attractive and well-accepted in Indonesia, especially because of the socio-cultural problems. It is essential to understand existing community practices and preferences and base behavior-changing and marketing interventions on that understanding (Prihandrijanti, 2006).

Furthermore, to have a sanitation system that is not only applicable but also sustainable, not only the choice of technology is important, but it is indispensable to enhance the contribution/participation of the community from the very beginning, including informed choice making (demand-responsive approaches, community participation) by all categories of society, in terms of technology, design of facilities, management, financing (cost and modes of payment) to generate a sense of ownership and responsibility for sustaining project benefits. Local communities can contribute indigenous, valid ideas for cost savings

in the project. According to the Inter-American Development Bank, "Citizen participation, properly channeled, generates savings, mobilizes financial and human resources, promotes equity and makes a decisive contribution to the strengthening of society and the democratic system" (Looker, 1998). If local participation can be encouraged, a strong sense of ownership by members of the community to the projects could be maintained. It is also very important to engage 'gatekeepers,' or influential community leaders and existing community organizations in promotion and education and improve women's participation. Women everywhere are more interested in sanitation improvements than men and tend to initiate or influence family decisions to invest in sanitation. Approaches that promote gender equity in community voice and choice are now proven to lead to more effective and better sustained project outcomes. In addition, studies have found that the toilet that people pay to get are better used and maintained than what they get for free. The more choices they have about what they pay for, the better they sustain it.

## **CONCLUSIONS**

Studies showed that despite high contamination potential and low environmental performance, septic tanks were still most preferred by the communities in Indonesia. However, because urban areas of many developing countries are growing rapidly, decentralizing wastewater treatment would give many advantages to be implemented. An optimized combination of centralized and decentralized wastewater treatment systems could also be a good alternative. In addition, cyclical, rather than linear approach includes the reuse of treated effluent for agricultural purpose should be promoted more intensively, because this would save non-renewable resources and energy, and bring the soil nutrients back into the

fields. It is crucial to ensure social, financial and technical sustainability of the approach, so that the option chosen to be applied can really be sustainable. To face the challenges of domestic wastewater treatment in big cities in developing world and achieve sustainability, local communities' participation plays the most important role.

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