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ASSESSMENT OF WASTEWATER MANAGEMENT IN MEKONG RIVER DELTA REGION

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Abstract

Mekong River Delta is an important delta of Vietnam, which is located at the downstream of Mekong River. With the high urbanization and industrialization, this region has been facing more intense environmental threats. This study was conducted to assess the current wastewater management in the region. Initial survey results revealed that there was only 8 wastewater treatment plants, meeting requirement of 6.9% of treatment demand, and the sewer coverage was 69%. The low environmental protection fees can not help cover the operation cost of sewerage system and wastewater treatment plants. Sludge treatment has been neglected. Therefore, more proactive in improving the wastewater sector and protecting their environment should be implemented from local authorities for the sustainable development in the future in the region.

Keywords: wastewater management; Mekong river delta; environmental protection.

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1. Introduction

Water pollution is a serious issue in Vietnam as a result of rapid industrialization and urbanization without adequate environmental management. For instance, annual monitoring data showed that environment in 4 main rivers and some lakes in Hanoi were polluted alarmingly, especially pollution of organic substances. Odor emitted from the rivers causes air pollution seriously [1, 2]. The domestic wastewater generated from the whole country is nearly 6 million m^3/d. In addition, there is industrial wastewater from 214 active Industrial zones [3]. According to MOC's report in 2015 [4], only 166 IZs have built the wastewater treatment systems (78%) as of December 2014. They are located mostly in Southern Economics Zones, Mekong Delta and Red River Delta. Besides, there are about 5000 craft villages in the Red River Delta (50%) and North Central and Coastal Central regions that have not had proper sewer systems and wastewater treatment plants (WWTPs) [4].

The Mekong River Delta region of Vietnam displays a variety of physical landscapes, but is dominated by flat flood plains in the south, with a few hills in the north and west. The average elevation from sea level is 1.0 – 1.8m. Being a low-lying coastal region, the Mekong Delta is particularly susceptible to floods resulting from the rise in sea level due to climate change. It has been predicted that, besides suffering from drought brought on by seasonal decrease in rainfall, many provinces in

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the Mekong Delta will be flooded by the year 2030. The most serious cases are predicted to be the provinces of Ben Tre and Long An, of which 51% and 49%, respectively, are expected to be flooded if sea levels rise by one meter [5]. Mekong Delta lies at the very downstream of Mekong River with complicated and interlaced rivers and channels.

Due to the specific geographic, most of the residents in urban areas of the Mekong Delta have the habits of disposing domestic wastewater directly into canals and creeks, making them heavily polluted and turning into black water. High water pollution is due to the discharge of different types of untreated wastewater. Study with the rivers nearby industrial parks exhibited BOD5 concentrations were 7 to 12 times higher compared to the environmental standard [6]. The chemical oxygen demand (COD) in Can Tho river or Cai Khe was up to 20 mg/L, higher than the allowed value in A1 column (QCVN 08:2008/BTNMT) [7]. About 10% of surveyed samples in their study showed number of Ecoli and Coliforms higher than allowable values for water sources for irrigation purposes (QCVN 08:2008/BTNMT – column B1).

With that in mind, the purpose of this paper is to evaluate the current wastewater management in Mekong Delta via questionnaire survey and interview and propose the technical solutions for the improvement of water environment in Vietnam Mekong River Delta (MRD) region.

2. Study methodology

2.1. Scope of the study

The main method used in the study was via survey and site investigation. The questionaires were prepared and sent to Departments of Construction (DOC) and Sewerage and Urban Environmental companies in 13 provinces (Long An, Tien Giang, Ben Tre, Dong Thap, Vinh Long, Tra Vinh, An Giang, Can Tho, Soc Trang, Hau Giang, Kien Giang, Bac Lieu, Ca Mau) in 2015. The provincial Department of Construction is the unit in charge of reporting on an annual basis about infrastructure management to Ministry of Construction by Law.

In addition to the survey by questionairs, other data was collected from secondary reports. Some of them are official reports such as data on General Statistic Offices (GSO) of Vietnam website, provincial websites and province social and economic reports. Basic information such as population, population density, areas, personal incomes, etc. were referred from GSO website. Basic information of the 13 provinces can be seen in Table 1.

The Mekong river delta region has significantly high population density of nearly 500 persons/km^2, much higher than the average number of 277 persons/km^2 in the whole Vietnam. This region mainly relies on agriculture [9]. The regional population accounts for about 25% of the whole Vietnam's population.

The average income is lower than the average income in Vietnam, which is about 37 mil. VND/person/year. Nevertheless, Mekong river delta has a lot of potentials for development and changes. The modernization and urbanization have altered its face to some certain extents but still keep the green space as necessary, compared to other parts of Vietnam.

2.2. Structure of questionnaire

The questionare covers some following contents: (i) Basic information; (ii) current wastewater collection; (iii) Current wastewater treatment technology; (iv) wastewater fee; (v) future investment plant and (vi) challenges and opportunities.

Table 1. Basic information of surveyed provinces [8]

	Area (km^2)	Average population (thous. pers.)	Population density (person/km^2)	Personal income (mil. VND)
Long An	4,495.00	1,484.70	330	38.90
Tien Giang	2,509.30	1,728.70	689	37.67
Ben Tre	2,359.80	1,263.70	536	29.40
Tra Vinh	2,341.20	1,034.60	442	26.64
Vinh Long	1,520.20	1,045.00	687	28.54
Dong Thap	3,378.80	1,684.30	498	32.29
An Giang	3,536.70	2,158.30	610	34.70
Kien Giang	6,348.50	1,761.00	277	36.19
Can Tho	1,408.90	1,248.00	886	40.38
Hau Giang	1,602.40	770.40	481	31.33
Soc Trang	3,311.60	1,310.70	396	30.58
Bac Lieu	2,468.70	882.00	357	27.83
Ca Mau	5,294.90	1,218.90	230	28.46
Average	3,121.23	1,353.10	493	32.53

The questionnaires were sent to all 13 provinces in Mekong Delta (DOCs and Sewerage and Urban Environment companies). 13 out of 13 DOCs sent the feedbacks while 8 out of 13 sewer and environment companies had properly answers, so they would be considered in the assessment.

3. Results and discussion

3.1. Wastewater collection

This data is unfortunately not available for all provinces as most of the DOC and Sewerage & Urban Environment Companies in MRD region find it difficult to have the exact data about the wastewater collection and sewer coverage. The data is mistransfered from time to time and all sewers are underground. Based on the feedback of 7 out of 13 provinces, the average sewer coverage is 69% and Household connection is 52% (Fig. 1). This average sewer coverage, which indicates the ratio of area having sewers and total area, in Mekong River Delta region is quite similar to that of the whole Vietnam of 70% [10]. Most of them are combined sewerage system like the other parts of Vietnam. Except for some new urban areas in cities of Can Tho va Soc Trang provinces, separate sewer systems are employed. The low household connection to municipal sewer system is one of main reasons leading to low influent quantity into the wastewater treatment plants (WWTPs). It should be noted that this data is for municipal domestic wastewater. The wastewater from rural areas is normally discharged into nearby canals for irrigation. The industrial wastewater is collected within the industrial parks, and should be treated before discharging into the municipal sewer system.

3.2. Wastewater treatment rate

According to urban population in 13 provinces in Mekong Delta, total estimated wastewater generation shall be about 760,000 m^3/d. Until now, the number of WWTP is quite limited. Result from the survey showed in Fig. 2, in which, there were only 8 plants in total, and 3/8 under operation with total

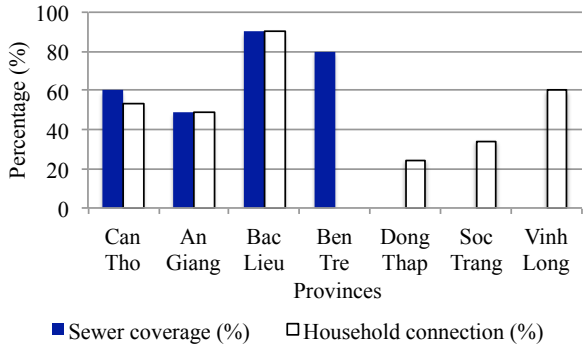

Figure 1. Sewer coverage and HH connection rate in some provinces in Mekong Delta (only data for sewer coverage of 4 provinces were available)

operation capacity of 52,500 m^3/d (6.9% of demand). Assuming all 8 WWTPs shall be completed in 2020, then it would raise the treatment rate to 15% by capacity. This number is lower than the average WWTP capacity nationwide, which is about 30% as of 2020 [11]. In remaining provinces, the local government has been actively calling for investment on this infrastructure to increase the WW treatment rate, or enhance the environmental protection.

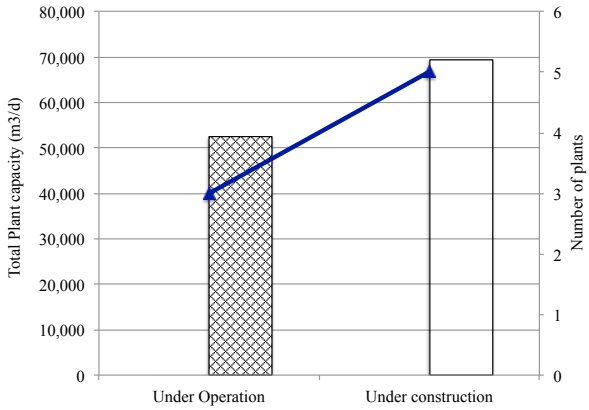

Figure 2. Number of WW treatment plants and total treatment capacity in Mekong River Delta region

In fact, the real wastewater treated could be lower than reported capacity due to incomplete sewer system or insufficient household connection as mentioned above. Some infrastructure investment projects could not complete the construction of main sewers because there were issues with site clearance and compensation.

The domestic wastewater treatment technologies to be applied in Mekong Delta are quite diversity, from low energy use such as Primary sedimentation (Soc Trang), Wastewater Stabilization Ponds (WSP) (An Giang), to energy-intensive technology such as Oxidation ditch (OD) and Sequential Batch Reactor (SBR). The operation costs of sedimentation and WSP are lower than those for OD and SBR due to lower energy use. Energy for pumps and blowers used in OD and SBR can account for 50-70% of operation cost [12]. Since the energy intensive technologies (76% by capacity) are applied, the WW management authority in An Giang, Can Tho, Hau Giang and Dong Thap should be carefully considered the financial source for cost recovery.

Beside the domestic WW treatment, the industrial wastewater is an issue in MRD region. Majority of industrial zones are located in Tien Giang, Vinh Long, Hau Giang and Can Tho provinces. The number of IZ and export processing zones are presented in Table 2. The treatment rate in Table 2 is calculated by diving the number of treatment plants in IZs by total IZs, that is why the number is high. If the treatment rate is determined by the ratio of total treated industrial WW and total generated industrial WW, the rate shall be only as low as 27% as the current capacity of all operation treatment systems are about 37.000 m^3/d according to survey data. Even though most of the provinces give priority in economic development to environmental protection, they have been making effort to call for investment in this infrastructure.

Table 2. Wastewater treatment

	2016			2017		
	Total zones (zone)	No of zones having proper WW treatment (zone)	Rate of proper treat-ment (%)	Total zones (zone)	No of zones having proper WW treatment (zone)	Rate of proper treat-ment (%)
Whole country						
Industrial zone	323	227	70.3	335	233	69.6
Export processing zone	4	4	100	4	4	100
Mekong river Delta						
Industrial zone	55	38	69.1	56	37	66.1
Export processing zone	6					

The wastewater from craft villages is not a great issue in Mekong Delta region since most of the craft villages are in the Red River Delta and Central coastal regions. Of over 5000 recognized craft villages nationwide, there are less than 100 craft villages existing in Mekong Delta basin. The main manufacture in these craft villages is bamboo and rattan processing and food (fish, coconut, seafood) processing, etc. [13]. The wastewater generated from food processing in Ben Tre, Soc Trang, Tra Vinh, Vinh Long is of the most concern. However, there is no data on the quantity of wastewater generated from these activities.

The healthcare wastewater treatment has been a bit better as the rate of district hospitals (103 hospitals) having treatment system is about 58%. The main treatment technology is CAS (72%) and applied for system capacity from 50 – 350 m^3/d [14].

3.3. Sludge treatment

Since there are only 03 active wastewater treatment plants in the region, the sludge generated from WWTPs is minimal. Accounting a number of rivers, channels and sewers as well as the sludge from households' septic tanks (ST), the sludge dredged from these rivers, channels, channels and ST should be significant. Data of sludge collection and treatment from 8 provinces (out of 13 provinces) are showed in Figs. 3 and 4.

In terms of sludge collection, Can Tho, An Giang and Hau Giang are among provinces that did this service better with more than 80% sludes dredging from sewers and lakes. Majority of provinces use

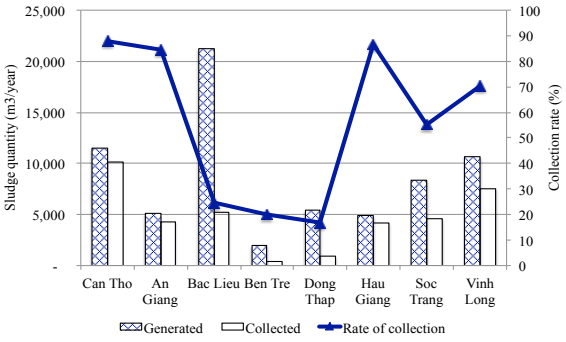

Figure 3. Sludge collection in MRD region

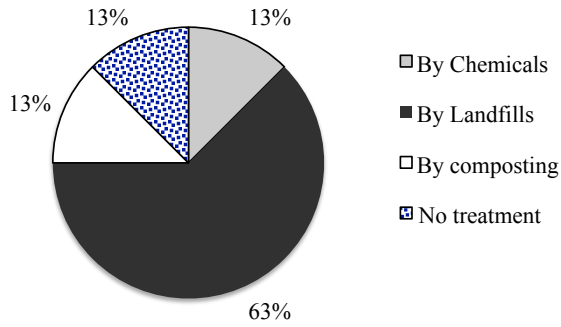

Figure 4. Sludge treatment methods

the method of landfill for sludge treatment as this technique is cheap and easy in operation. However, composting should be recommended for better recycle and reuse of materials.

3.4. Wastewater tariff

Since the sanitation has been not considered the most concern in Mekong delta, the environmental protection fee is quite low (< 10%). It should be noted that the EP has just recently included in the water bill and it has been suggested by Law to be less than 10% and increased with phases (Decision No 25/2013/NĐ-CP issued on 29/3/2013 on EP for wastewater management). In general only 60-70% of the EP is used for environmental protection and contributed to the Environment Protection Fund. Part of them is used for sewer dredging and for research on wastewater treatment technologies. That is the reason why the wastewater management in these provinces has not been much paid attention due to the limited fund.

In consideration of the cost recovery of these provinces, evaluation of economic condition in these provinces has been conducted via assessing the personal income (Table 1). It should be noted from Tables 1 and 3 that among the 13 provinces, only Long An, Tien Giang, Kien Giang and Can Tho seems to have financially potential for cost recovery for any investment in wastewater collection and treatment.

3.5. Proposal of future wastewater management

Based on the strategy and current wastewater management in provinces in Mekong Delta, it is recommended to construct new separated sewerage systems (SSS) in newly constructed areas and to rehabilitate the existing combined sewers by adding interceptors and combined sewer overflows (CSOs). They give priority for the construction of WWTP and finalization of drainage and sewerage systems in provincial cities first, followed by smaller towns (grade III, grade IV, and grade V cities) (Fig. 5).

For existing combined sewers in urban cities, it is recommended to rehabilitate the inner rivers and channels for better drainage; upgrade the combined sewers by installation of interceptors and CSOs to reduce the quantity of wastewater for treatment. CSOs would need to be designed in a way to prevent salinity invasion. For areas which have not had sewers, the use of SSS would be the best practice to not only reduce the wastewater to be treated but also improve the quality of influent wastewater to the treatment plants.

One thing should be noted that the flooding is something the Mekong Delta people desire for since it creates sources of fish products and brings nutrient soils for farming in downstream provinces.

Table 3. Current Environmental protection fee

No	Provinces	Water tariff (VND/m^3 water)***	Environmental Protection Fee (EP)
1	Long An	6150	5%
2	Tien Giang	6200	10%
3	Ben Tre*	8000	(2.5%) 200 VND/m^3
4	Tra Vinh*	6500	6%
5	Vinh Long	6600	5% - inclusive
6	Dong Thap	8000	< 10%
7	An Giang	4500	3% - inclusive
8	Kien Giang**	6000	6%
9	Hau Giang	6500	EP only for industrial WW
10	Can Tho**	4800	(10%) 300-500 VND/m^3
11	Soc Trang**	4900	EP only for industrial WW
12	Bac Lieu	6500	5% EP - exclusive
13	Ca Mau	5400	EP - not A/V
	Average	6150	

Note: *Data in 2012, **Data in 2013; ***The lowest level for domestic use

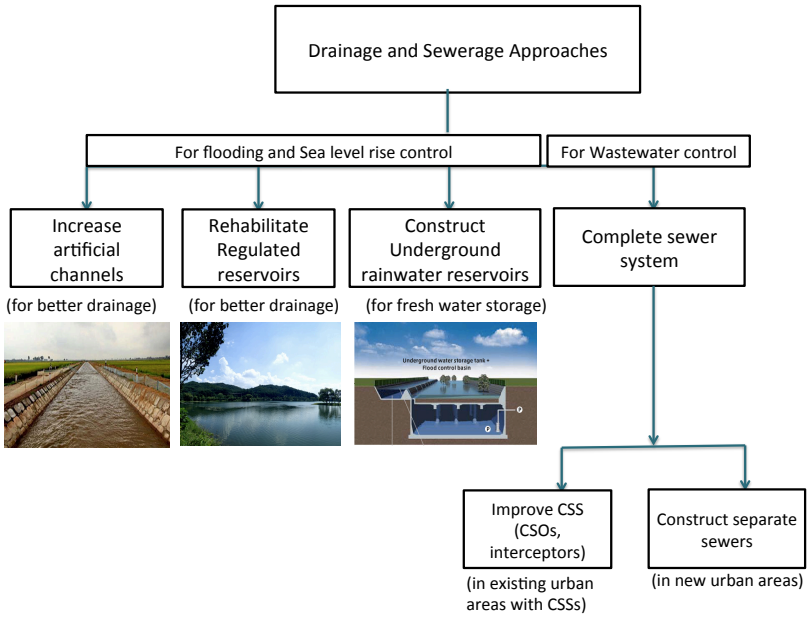

Figure 5. Drainage and Sewerage approaches for MRD region

Therefore, no flood would be a problem for them. The only thing we can do is to drain the storm-water as soon as possible to natural/artificial channels and regulated reservoirs and via drainage pumping stations. Storm-water pumping stations should be installed at severe inundation points. In addition, the utilization of underground rainwater reservoirs should be introduced. This model has been applied for decades in Korea, Japan, United Kingdom and Australia [15, 16]. This model is not only control the

runoff quickly but also a water supply source for multi-purposes including plant and road watering, firefighting, etc.

As this region has been greatly impacted by climate change, the management of wastewater should integrate the adaptation with climate change. The selection of proper technologies should consider the following key features of Mekong Delta: (i) Potential of flooding and sea level rise (climate change impact); (ii) Low cost recovery ability (based on personal income and other economic conditions); (iii) Lack of required operation skills because there are no active WWTPs to date; (iv) Flat plain in most areas with complicated and interlaced rivers and channels (geological and hydrological conditions) and (v) Culture and style of living of Mekong Delta's people. The proposed wastewater treatment technologies as presented in Fig. 6.

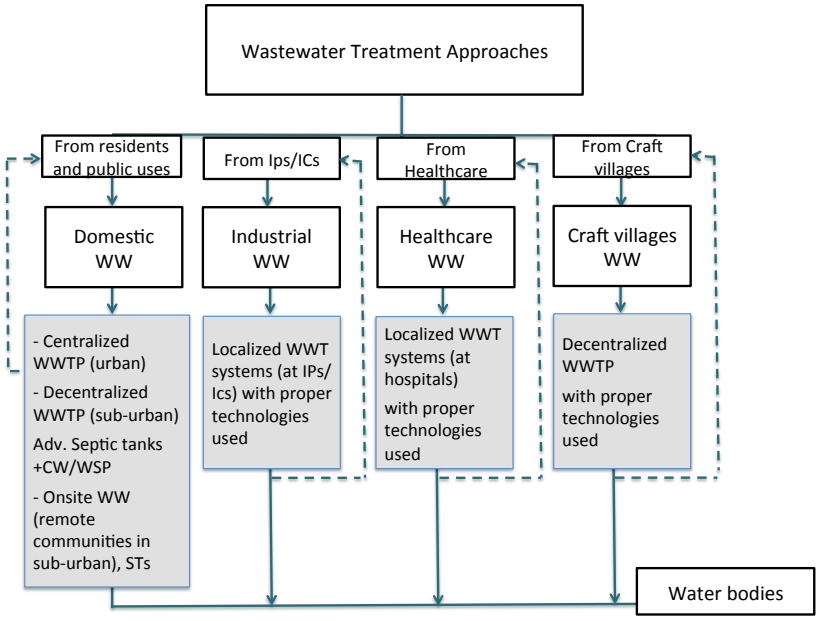

Figure 6. Wastewater treatment for MRD region

At centralized domestic WWTPs, some low energy technologies could be employed such as Wastewater Stabilization Ponds (WSP) and/or Constructed Wetland (CW). Nevertheless, due to the great land use, these techniques can be applied only for cities, which have assigned enough lands for WW treatment in the City's General Masterplan. In crowded urban where land is limited, some other compact technologies can be used such as oxidation ditch (OD), Anaerobic-Oxic tank (AO), Anaerobic-Anoxic-Oxic (AAO), Sequential Batch Reactor (SBR), Trickling Filter, etc.

In comparison with investment cost and O&M cost internationally, these numbers might be different due to the cost of land, compensation cost for site clearance, operation and maintenance skills as well as management mechanism. The investment and operation cost of AAO technologies normally lower or similar to SBR technology in practical. It is high in Vietnam due to low capacity scale (less than 5000 m^3/d) and this is located in the center area of Hanoi city, for the case of Kim Lien or Truc Bach WWTPs.

At industrial parks, since the centralized industrial WWTP often handle the secondary effluent from the factories' primary treatment systems (already met the national technical regulations QCVN 40/2011/BTNMT, level B or level C), this plant acts as a polishing step before discharging into the

Table 4. Summary of Investment cost and Operation cost of several centralized WW treatment technologies in Vietnam [17]

Technologies	Investment cost ($/m^3)	Operation cost ($/m^3)
WSP	500 - 650	0.10 - 0.15
WSP-CW	400 - 600	0.10 – 0.25
CAS (aeroten)	1000 - 1200	0.15 – 0.35
Biofilter (BF)	800 - 900	0.15 – 0.25
AAO	1600	0.35 – 0.50
OD	600 - 750	0.15 – 0.65
SBR	700 - 1000	0.15 – 0.50

environment. It, however, plays important role in some emergency cases where the primary treatment fails or has trouble in operation. Technologies to be applied can be WSP (if land available) or CAS. For hospital WWT, the compact and mechanized treatment technologies often are recommended due to the land and odor constraint since the treatment system is often located inside the hospital. In Vietnam, the common technologies used are CAS, membrane bioreactor (MBR), trickling filter (TF) and moving bed bioreactor (MBBR). They have advantages in terms of footprint and odor control.

Decentralized wastewater treatment (normally at smaller scale of capacity) can be applied for sub-urban where the wastewater generation is small, craft villages and from scattered households. The advanced septic tank (in modules) and CW/lagoon are often the typical treatment models for this approach. The capital cost varies from \$500–\$700/m^3. The main advantage of decentralized wastewater treatment is the lower capital cost for sewers since the sewers are shorter, number of pumps is reduced. These treatment technologies require no energy for pumps or chemical cost but labor cost only. Therefore the O&M cost is very low. In the future, when the city becomes more developed and crowded and treatment demand is higher; these decentralized WWTPs can be turned into intermediate wastewater pumping stations for delivery of wastewater to a centralized WWTP.

Onsite wastewater treatment implies the application of existing septic tanks. It should be noted that septic tank coverage in Mekong Delta is almost 100% (except for houses along rivers). By taking advantages of the onsite treatment unit (i.e. septic tanks), the rate of wastewater treated would be improved. It is worth noting that the suspended solids (SS) and BOD removal by septic tanks are only 45% and 25% respectively. However, using upgraded septic tanks is better than having no wastewater treatment before discharging, knowing that the centralized wastewater treatment approach is quite expensive for some poor provinces.

4. Conclusions

Initial survey results for Mekong River Delta revealed that many things should be done for improvement of wastewater management in Mekong Delta. With only 8 wastewater treatment plants meeting only 6.9% of treatment demand and sewer coverage of 69%, in addition to high risk potential of climate change (seawater rise and salt instruction), local authorities in 13 provinces in Mekong Delta should be more active in applying flexible and effective management approach in wastewater sector.

In technical aspects, based on their economic conditions, the cost recovery when investment in wastewater – related projects is quite low, the selection of wastewater collection and treatment tech-

nologies would go for low cost ones, for instances, lagoons or constructed wetlands. Taking advantages of existing onsite WW treatment (septic tanks) would also be the viable approach for cleaning up the "black channels" in cities of Mekong Delta from now until 2030.

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