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SUSTAINABLE WATER AND SANITATION SERVICES
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Total flow of N and P in Vietnam urban wastes

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The amount of organic matters, N and P, is quite significant in urban wastes, especially in wastewater and solid wastes. It was found from this study that their production was about 302,241 ton of TN/day and 54,682 ton of TP/day. During the urbanization and industrialization, these numbers continue to increase. These nutrient matters can be used in agriculture as well as in other practices. Nevertheless, they will become pollutants when being discharged to surrounding environment (rivers, lakes, etc.) as they cause water eutrophication and increase risks for water supply.

The context of wastes treatment and management in Vietnam urban areas

Vietnam's population currently is about 88 million, including about 28 million of urban residents (31%) and about 60 million of rural residents (69%). Based on the development growth rate in rural and urban areas, it is apparently that the urbanization has been increasing in Vietnam. The urbanization rate has increased from 24% in 2000 to 30% in 2009. Urban wastes, therefore, could be threats to urban environment if there is no proper solution to control the pollutants (such as nitrogen N, phosphorous P, etc.) from leaking out to the environment.In urban areas, the N and P are normally generated from municipal wastewater and solid wastes as discussed in the followings.

Wastewater (WW) collection and treatment

The most common sewage system in Vietnam's urban areas is the combined one. Most of them were built about 100 years ago, normally for storm water collection. At present, they have been used for both storm water and wastewater collection, including open canals, lakes and combined sewer overflow (underground channels), concrete pipes, trenches with concrete lids, which are poorly maintained, repaired, causing severe deterioration. The construction of new sewers has been done improperly, not based on a long-term planning and hasn't meet the demand of urban development. According to the Report on Water Sector Assessment (ADB, 2009) on the basis of Ministry of Construction (MOC) and Vietnam Water Supply and Sewerage Association (VWSA)'s data, the percent of sewerage coverage is approximately 40-50% and varying from 70% in big cities to 1-2% in small towns. Among 63 cities (including 5 central ones and 58 provincial ones), 32 cities have executed sewerage and sanitation projects funded by ODA. Most of these projects involved rehabilitation and improvement of the existing sewerage systems. Only some applied the separate sewerage system, for instance, the ones in Buon Ma Thuot city and Dalat city.

Eighty percent of households haves septic tanks to treat black water, however, the septic tanks operate at low capacity, hence the sludge is not treated and removed properly. Most of wastewater from the septic tanks has sludge, causing sludge settlement in municipal sewerage system and bad smell during dry season. The grey water and storm water are discharged directly to either municipal sewerage system or nearby receiving bodies.

Only a few cities have integrated sewerage system that composes sewer network and wastewater treatment plant (WWTP). As of the end of 2013, there were about 20 wastewater treatment plants (WWTP) which treat approximately 595,000 m3/d (about 18% of total WW generated) (Table 1). The majority of WWTP uses conventional biological treatment process (biological ponds, bio filters, etc), mainly remove such pollutants as SS, BOD, …and coliforms. Some of them combine N removal by applying AO (Anoxic

Oxic tank) or other processes like SBR (sequencing batch reactor), OD (oxidation ditch), etc. Advanced oxidation ditch has been introduced and constructed in some cities' projects.

Table 1. Operating WW treatment plants in Vietnam

No	Plant	City	Year startup	Capacity		Sewer type	Treatment process/technology
				Designing	Functioned		
1	Kim Lien	Hanoi	2005	3,700	3,700	CSS	AAO
2	Truc Bach		2005	2,500	2,500	CSS	AAO
3	North Thang Long		2009	42,000	7,000	CSS	AO with nitrification
4	Yen So		2012	200,000	120,000	CSS	SBR
5	Binh Hung	HCM City	2009	141,000	141,000	CSS	CAS
6	Binh Hung Hoa		2008	30,000	30,000	CSS	Aeration. Ponds + Maturation Ponds
9	Son Tra	Da Nang	2006	15,900	15,900	CSS	Anaerobic Pond w/float cover
10	Hoa Cuong		2006	36,418	36,418	CSS	Anaerobic Pond w/float cover
11	Phu Loc		2006	36,430	36, 430	CSS	Anaerobic Pond w/float cover
12	Ngu Hanh Son		2006	11,629	11,629	CSS	Anaerobic Pond w/float cover
13	Bai Chay	Quang Ninh	2007	3,500	3,500	CSS	SBR
14	Ha Khanh		2009	7,000	7,500	CSS	SBR
15	Da lat	Da Lat	2006	7,400	6,000	SSS	Imhoff tank + Trickling Filter
16	Buon Ma Thuot	BMT	2006	8,125	5,700	SSS	Stabilization Ponds (AP,FP,MP)
17	Bac Giang	Bac Giang	2010	10,000	8,000	CSS	OD
18	Phan rang	Ninh Thuận	2011	5,000	5,000	CSS	Facultative Ponds + Maturation Ponds
19	Bac Ninh	Bac Ninh	2013	17,500	17,500	CSS	SBR
20	Thu Dau Mot	Binh Duong	2013	17,650	5,000	SSS	ASBR

Note: CSS: Combine sewerage system, SSS: Separated sewerage system, AAO: Aerobic Anoxic Oxic system, SBR: Sequencing Batch Reactor, CAS: Conventional Activated Sludge, OD: Oxidation ditch, ASBR: Advanced SBR. (Source: World Bank (2013) and Tran Duc Ha (2013)).

Solid waste (SW) treatment

The solid waste generation in Vietnam urban areas has also increased dramatically as the country strives to attain an industrialized nation status by the year 2020. The total generated quantity was reported to be approximately 26,224 tons/day as of 2010 (MONRE, 2011). It is estimated that the proportion of MSW disposed at open dumping sites and landfills accounting for 76-82% of the total collected MSW quantity. There are about 98 open dumping sites and landfills in operation in the whole country and most of them located in urban areas. Of which, there are only 16 sanitary landfills and the remaining are open dumping sites and unsanitary landfills (Nguyen et al., 2013). Less than 10% of MSW is composted. Most of composting plants are not operating at full capacity since there is a difficulty with the selling of composting products due to several reasons such as inadequate market survey prior to construction of the facilities, inadequate monitoring of the quality and quantity of the compost being produced, and lack of attention by the marketing organization to the distribution of the compost and to consumer feedback. Incineration is not

considered a best practice in Vietnam due to the operation cost and air pollution problems. And unfortunately, recycling of wastes has not been a common habit of Vietnam urban residents.

Nutrients (N and P) from untreated wastewater and solid wastes can create a lot of environmental issues such as water pollution (eutrophication), photochemical smog, acid precipitation and soil acidification and change in biodiversity. The control of N and P flow in a way to minimize the impact on the environment and maximize their reuse for fertilization has been of great interest.

N and P loading rate in municipal wastes

Basic diagram for determination of total N and P flows in municipal wastewater and solid waste is presented in Figure 1.

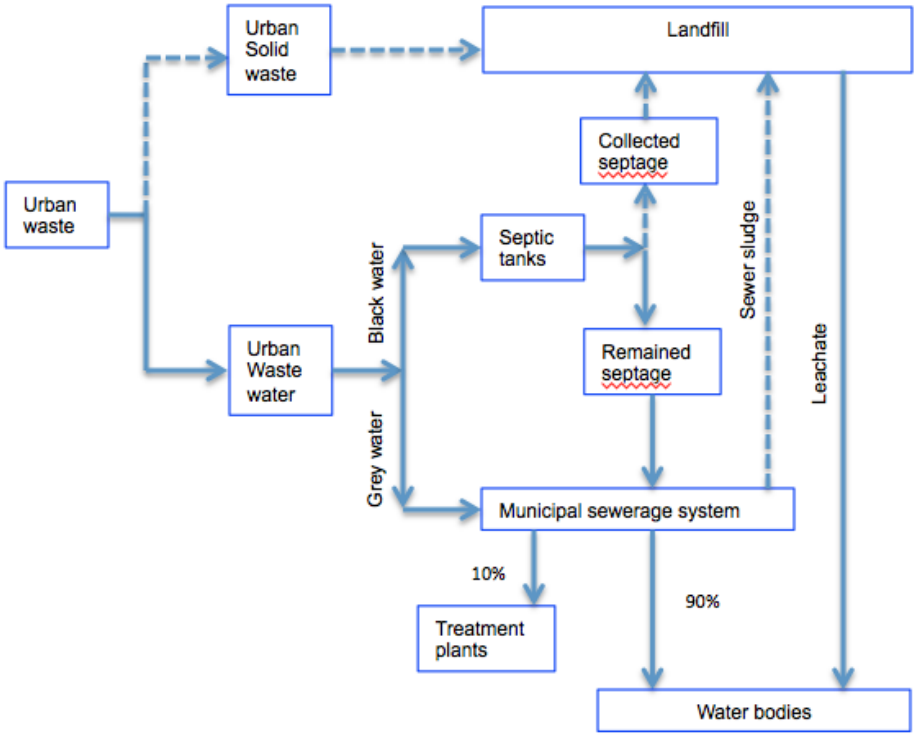

Figure 1. Mass balance for determination of total N and P in municipal wastes

N and P from wastewater

Since there is no survey or monitoring data on N and P generation, the N and P amount basically are calculated based on the unit waste production per person per day. According to Vietnam criteria for Drainage and sewerage: Indoor and Outdoor network – Design Standard TCVN 7957:2008, N-NH_4 generated per person per day is 8 grams while P generated is 0.78 g/person/day.

With approximate 2.8 million of urban residents in Vietnam, the amount of N and P production from wastewater would be 224 tons/d and 22 tons/day, respectively.

N and P from solid wastes

Based on QCVN 01:2008/BXD - National Standard on Construction Planning, the average solid waste generation rate for both houses and commercial buildings is 1.0 kg/person/day. As the result, the total municipal solid waste is approximately 28,000 ton/day. The average moisture content of Vietnam municipal garbage is 55-60% (Cu and Tran, 2008) and specific gravity is 480 – 580 kg/m3 (CEETIA, 2001); the N content in garbage is 0.45-0.75% of dry weight and P_2O_5 content is 0.45-0.65% of dry weight (Nguyen and Tran, 2004). Therefore, total N and P in municipal solid waste are 70.56 ton N/day and 26.9 ton P/day, respectively.

N and P from Fecal sludges

Majority of urban households have septic tanks. The fecal sludge from septic tanks has been estimated in several studies in big cities such as Hanoi, Hochiminh city, Hai phong (Table 2).

Table 2. Fecal sludge generation in 3 big cities

No	Items	Hanoi	Hai Phong	Hochiminh city
1	Number of households (HH) in city	489,362	232,760	1,540,938
2	Number of users per HH	4.7	4.1	4.8
3	Number of HHs having septic tanks	430,638	218,795	1,017,019
4	Total volume of sludge to be emptied, m3/year	280,376	166,466	894,087
5	FS collected per year	189,000	80,569	335,756

Source: Nguyen et al., 2011

The N and P concentrations are quite significant. It can be seen in below fecal sludge characteristics table.

Table 3. Characteristics of septic tank's sludge

No	Index	Value
1	Moisture[1], %	90
2	Specific gravity[1], ton/m3	1.4-1.5
3	Total N[2], % of dry weight *	0.97
4	Total P[2], % of dry weight *	0.71

Note: * In septic tank's fecal sludge of households after years in use.

Source: 1Nguyen et al., 2008; 2CEETIA, 2003

Based on the study, the generation rate of septic tank's sludge is estimated 0.4 m^3/tank/year and collection rate is 0.28 m^3/tank/year. Assumingly each HH has averagely 4 persons, and each HH has one septic tank as regulated by Vietnam regulations, the number of septic tanks are 2.8 mil/4 = 7 mil. of tanks.

If the collection rate is 70%, the total N from septic tank's fecal sludge is calculated as below:

0.4 m^3/tank/year x 1.4 ton/m^3 x 7,000,000 tanks x 70% x 90% x 0.97%= 2661.68 ton/year = 7.292 ton TN/day.

And, the total P from septic tank's fecal sludge is calculated as:

0.4 m3/ tank/year x 1.4 ton/m3 x 7,000,000 tanks x 70%x 90% x 0.71%= 1948.24 ton/year = 5.337 ton TP/day.

From sewers' sludge

It is reported by VWSA for the year of 2011 that the covering rates of sewers in urban areas are 0.25 m/person for Special cities (e.g. Hanoi, Hochiminh city, Da Nang, Hai Phong, etc.) and 0.05-0.08 m/person for other cities.

If the covering rate is averagely 0.09m/person, total sewer length of all cities in our country would be 2,520,000 m (2520 km). Based on the sludge dredging amount from Hanoi sewers in 2010, it is estimated that the sludge settled in sewer system is 240 ton/km/year. If the dredging rate is 80%, the total sludge from urban sewer system is:

2520 x 240 ton/km x 0,8 = 483.840 ton/year =1325,6 ton/day.

In which, the moisture of sludge is 86%, accordingly the dry sludge accounts for 14% (Tran Duc Ha, 2011).

The nutrient content of this sludge was reported by some studies as in Table 4.

Table 4. Nutrient content in urban sewers'sludge

No	Index	Hochiminh city1	Hanoi2	Average3
1	TN, mg/kg	1901	2380	2100
2	TP, mg/kg	2841	1950	2420

Source: [1]Chu Quoc Huy, 2007; [2]Nippon Koei, 2005; [3]Tran Duc Ha, 2011

Based on the above table, the TN in Vietnam urban sewer sludge can be determined as follows:

1325.6 x 0.14 x 0.0021 = 0.389 ton/day

TP in Vietnam urban sewer sludge can be determined as:

1325.6 x 0.14 x 0.0024 = 0.4454 ton/day

Whereas 0.14 is the dry sludge percent.

Total N and P in all kinds of municipal wastes from Vietnam urban areas are illustrated in Table 5 and Figure 2.

Table 5. Total N and P in Vietnam urban wastes

Index	Wastewater	Sewer sludge	Septic sludge	Solid waste	Total
TN, ton/day	224	0.389	7.292	70.56	302.241
TP, ton/day	22	0.445	5.337	26.9	54.682

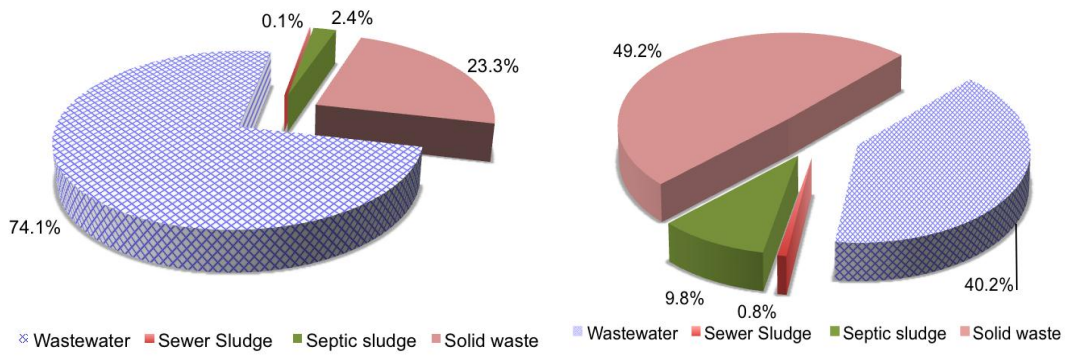

Figure 2. WEDC - Contribution sources to total N (left) and P (right)

The total N and total P generated from municipal waste in Vietnam were estimated 302.2 ton/day and 54.7 ton/day, respectively. While wastewater contributes the most to the N flow, the solid waste play the key role in total P generation.

Strategies on N and P management in urban areas

In reality, the nutrient flow in urban areas has not been as substantial as in rural areas where husbandry and cultivation play important roles and produce significant N and P daily. The consideration of controlling the nutrients in urban areas was raised as more and more urban lakes/surface water bodies are in danger of eutrophication. Besides, N and P are essential nutrient sources for planting and cultivation. Therefore, it is

recommended to develop strategies for nutrient control in a way to reuse them for fertilization. Some initiatives could be considered such as: (i) Treatment of urban wastewater by eco technologies to optimize the growth mass of algae and plants and maximize the reuse of N; (ii) Maximize the P recycle from solid waste and sludge treatment and (iii) Apply integrated control and treatment of fecal sludge, sludge from wastewater treatment plants, sewer sludge and organic wastes together would be the best option for Vietnam urban at present.

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