

Integrated municipal solid waste management approach in adaptation to climate change in Mekong Delta

Cách tiếp cận quản lý tổng hợp chất thải rắn nhằm ứng phó biến đổi khí hậu ở Đồng Bằng Sông Cửu Long

Review paper

Nguyen, Xuan Hoang*

Department of Environmental Engineering, College of Environment and Natural Resources, Can Tho University (Campus II). 3/2 Str., Can Tho City, Vietnam

A fast increase of municipal solid waste (MSW) has become the most concerning environmental problem in Vietnam, especially in the Mekong Delta region, that is considered one of the most vulnerable deltas to climate change in the world. There are 12 provinces and one central city in MD that occupy about 12% of the whole area of the nation with 5% of MSW generated. However, there is no currently effective management system in place for treatment and management of MSW in the MD. Landfill is the sole treatment option for MSW right now. With a low-level plain, MD is facing the most serious environmental problem in the near future with an effect of climate change and sea level rising. The landfill should not be considered for long-term use in this area. Suitable treatment options for MSW should be applied together with other solutions for reuse, recycling and reduction of MSW as well as pollution prevention issue. An integrated MSW management approach in adaptation to climate change is considered necessary.

Sự tăng nhanh chất thải rắn đã trở thành vấn đề vấn đề môi trường được quan tâm nhất ở Việt Nam, đặc biệt là ở khu Đồng bằng Sông Cửu Long một trong những đồng bằng dễ bị tổn thương bởi sự biến đổi khí hậu nhất trên thế giới. Đồng bằng Sông Cửu Long có 12 tỉnh và một thành phố trực thuộc trung ương, chiếm 12% diện tích của cả nước với khoảng 5% lượng chất thải rắn phát sinh. Tuy nhiên, hiện nay chưa có một hệ thống quản lý hiệu quả cho chất thải rắn ở khu vực. Bãi rác là lựa chọn xử lý duy nhất ở thời điểm này. Với cao độ thấp, Đồng bằng Sông Cửu Long đang đối mặt với ảnh hưởng nghiêm trọng của các vấn đề môi trường trong tương lai gần bởi ảnh hưởng của sự biến đổi khí hậu và nước biển dâng. Về lâu dài bãi rác không nên sử dụng ở khu vực này. Các lựa chọn xử lý thích hợp cho chất thải rắn cần được áp dụng cùng với các giải pháp khác như tái sử dụng, tái chế và giảm thiểu chất thải rắn cũng như các giải pháp ngăn ngừa ô nhiễm.

Keywords: municipal solid waste management, Mekong Delta, integrated solid waste management, climate change

1. Introduction

Located in the southern part of Vietnam, Mekong Delta comprises 13 provinces and city, including the provinces of Long An, Tien Giang, Vinh Long, Ben Tre, Dong Thap, Tra Vinh, Hau Giang, Bac Lieu, Soc Trang, An Giang, Kien Giang, Ca Mau, and Cantho city with the land area of 39,712 km² making up 12.1% of the whole

country area. The population was about 17.3 million people in 2006, occupying 28% of the whole country population (CIA Factbook, 2010). The Mekong River Delta is one of the most important two rice granaries of the country (beside Red River Delta in the North), that has an agricultural output accounting for 50%, food production for 90% and aquaculture products for 70% of the whole nation output (Nguyen and Le, 2011). Presently, MSW has become one of the most concerning environmental problems in the cities. The fast urbanization development wherein irrational planning for residential, industrial, disposal sites, etc. has aggravated the existing intrinsic environmental problems in the region. Moreover, the delta is a low-level plain with less than three meters above sea level and is criss-crossed by canals and river system. About 10,000 km² of the delta are under rice cultivation, making the area one of the major ricegrowing regions of the world. The southern tip, known as Ca Mau Peninsula, is covered by dense jungle and mangrove marsh or wetland.

In addition, flooding will be of most concern in the future. Most of the regions are located in a very low elevation (below +2.0 m), except some hilly areas in An Giang and Kien Giang provinces. The high water level of the East Sea tide (rising up to +2.14 m) is obviously affecting the Mekong Delta basin along the main rivers. The increasing of flooding with higher frequency and magnitude, sea water intrusion with high tide, contaminated soil, sea level rise, and seasonal tropical storms are major problems in MD in the future (Nguyen, 2007). According to the IPCC (IPCC, 2007) interim estimates, in case of sea level risesup to 1m, an area of 15,000 to 20,000 km² in the Mekong Delta would be flooded, resulting in the situation that millions of people have to move their housings and agricultural production being seriously reduced (Nguyen and Nguyen, 2009).

The fast increasing of MSW quantity and the generation rate in the region have put potential challenges to the management of MSW in urban areas. In addition, increased flooding in the future will cause more difficulties for the treatment and management of MSW, which are still underdeveloped.

2. MSW generation and management

2.1 MSW generation

The total amount of MSW generated annually in Vietnam approximates 15 million tons, that accounts for 80% and the remaining fractions are industrial waste (17%), healthcare waste from hospitals (0.14%) and others. In Mekong Delta, the average quantity of MSW is rather low in comparison to those of big cities in Vietnam. The generation rate varies from 0.3 kg/capita-day for the whole province (including rural areas) to 1.2 kg/capita-day for the urban area only (MONRE, 2010). The yearly MSW generation in Mekong Delta is about 600,000 tons, which is approximately 1,645 tons per day. This accounts for about 5% of the total amount of MSW produced nation-wide (MONRE, 2010; Nguyen and Le, 2011). It is estimated that the average MSW generation rate increases about 10 - 16% every year.

Organic matter	Paper	Metal	Glass	Textile	Plastic and rubber	Ceramic and brick	Hazardous waste	Others
79.65	2.79	0.70	1.52	1.86	9.57	3.10	0.03	0.76
57.30	4.50	0.10	0.50	1.40	6.10	2.10	-	28.00
70.35	4.12	0.78	0.66	3.11	7.24	9.63	-	4.11
77.53	3.89	0.23	0.21	-	6.37	2.14	0.06	9.57
76.30	5.10	0.37	0.70	-	13.63	2.68	0.15	4.08
73.85	6.50	1.75	0.85	-	5.20	1.60	0.3	9.95
87.25	2.05	0.45	-	-	3.16	2.04	-	5.05
66.25	11.50	0.55	4.00	6.50	9.45	0.75	-	1.00
53.34	4.51	4.59	4.91	-	4.44	10.81	2.78	14.62
82.60	1.80	0.40	0.90	1.50	5.70	1.60	4.00	1.50
72.52	6.38	1.27	1.64	1.29	7.69	7.49	-	1.72
NA	NA	NA	NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA	NA	NA	NA
	Organic matter 79.65 57.30 70.35 77.53 76.30 73.85 87.25 66.25 53.34 82.60 72.52 NA NA	Organic matterPaper79.652.7957.304.5070.354.1277.533.8976.305.1073.856.5087.252.0566.2511.5053.344.5182.601.8072.526.38NANANANA	Organic matterPaperMetal79.652.790.7057.304.500.1070.354.120.7877.533.890.2376.305.100.3773.856.501.7587.252.050.4566.2511.500.5553.344.514.5982.601.800.4072.526.381.27NANANANANANA	Organic matterPaperMetalGlass79.652.790.701.5257.304.500.100.5070.354.120.780.6677.533.890.230.2176.305.100.370.7073.856.501.750.8587.252.050.45-66.2511.500.554.0053.344.514.594.9182.601.800.400.9072.526.381.271.64NANANANA	Organic matterPaperMetalGlassTextile79.652.790.701.521.8657.304.500.100.501.4070.354.120.780.663.1177.533.890.230.21-76.305.100.370.70-73.856.501.750.85-87.252.050.4566.2511.500.554.006.5053.344.514.594.91-82.601.800.400.901.5072.526.381.271.641.29NANANANANANANANANA	Organic matterPaperMetalGlassTextilePlastic and rubber79.652.790.701.521.869.5757.304.500.100.501.406.1070.354.120.780.663.117.2477.533.890.230.21-6.3776.305.100.370.70-13.6373.856.501.750.85-5.2087.252.050.453.1666.2511.500.554.006.509.4553.344.514.594.91-4.4482.601.800.400.901.505.7072.526.381.271.641.297.69NANANANANANANANANANANANA	Organic matterPaperMetalGlassTextilePlastic and rubberCeramic and brick79.652.790.701.521.869.573.1057.304.500.100.501.406.102.1070.354.120.780.663.117.249.6377.533.890.230.21-6.372.1476.305.100.370.70-13.632.6873.856.501.750.85-5.201.6087.252.050.453.162.0466.2511.500.554.006.509.450.7553.344.514.594.91-4.4410.8182.601.800.400.901.505.701.6072.526.381.271.641.297.697.49NANANANANANANA	Organic matterPaperMetalGlassTextilePlastic and rubberCeramic and brickHazardous waste79.652.790.701.521.869.573.100.0357.304.500.100.501.406.102.10-70.354.120.780.663.117.249.63-77.533.890.230.21-6.372.140.0676.305.100.370.70-13.632.680.1573.856.501.750.85-5.201.600.387.252.050.453.162.04-66.2511.500.554.006.509.450.75-53.344.514.594.91-4.4410.812.7882.601.800.400.901.505.701.604.0072.526.381.271.641.297.697.49-NANANANANANANANA

The composition of MSW is also different in urban and rural areas. All of MSW in Mekong Delta is not classified at source, so that some hazardous components are mixed into non-hazardous waste. Most of recyclable or reusable waste are collected and transferred separately into an unofficial recycling centre. These can be plastics, metals, glass, etc.; however there is no data on these kinds of materials. In addition, the major MSW treatment and management in the MD is simply landfilling with nonclassified MSW disposal.

There is a high percentage of organic matter (54 - 87%) in the waste and also diversified waste fractions (organic matter, paper, metal, glass, textile, plastic and rubber, ceramic and brick, hazardous and miscellaneous) that characterizes the MSW in the cities in Mekong Delta region (Table 1).

Landfilling in the MD can be considered as open dumpsites. Sanitary landfill is well known as engineering landfill with a good design for environmental protection; however, it is not present in the MD up to now. Furthermore, rainfall in the region has high levels (the average rainfall is about 1,733 mm). The highest average rainfall occurs in Ca Mau and Kien Giang (2,200 - 2,500 mm)and the lowest rainfall is 1,300-1,500 mm in Dong Thap, Tien Giang and Ben Tre provinces. According to statistic data, average rainfall has a trend of increasing by year in the region (SIHYMETE, 2010).

2.2 MSW management system

The local People's Committee (PC) bears the responsibility for the state administrative management, provincial coordination and leading orientation of the MSW management policy and project management. They can make investment and support equipment and technologies for MSW treatment systems. Besides, the Department of Natural Resources and Environment (DONRE) is an institution at province level, directly subordinate to the Ministry of Natural Resources and Environment (MONRE), that acts on the cooperation, support, and technical guidance. In addition, this institution administratively acts under the PC. The DONRE plays an important role in the waste management activities including environmental quality monitoring, management and implementation of environmental protection. URENCO is a company under DONRE's control or the local PC that is directly responsible for the collection, transportation and treatment of MSW in the provinces/cities (Nguyen and Le, 2011).

As mentioned above, landfill is the sole solution for MSW and there are no sanitary landfills in the region. The existing landfills in the region can be considered as open dump sites. It is estimated that there are 1 to 2 urban landfills in each province or central city, so that there are more than 15 landfills available in the MD at present. In addition, the MSW management process is obsolete and underdeveloped. The waste generated at sources is collected and transferred to the landfill via a transfer station, which is called "meeting point", by vehicles such as handcarts, forklift trucks, garbage compressors, specialized trucks, etc. for the shipment to the disposal site (Figure 1).



Figure 1. Waste collection activities in Mekong Delta region (source: Nguyen and Le, 2011) a) plastic containers b) recycling centre c) garbage collection by boat d) waste collector in a market e) waste collection by handcarts f) "meeting points" on the street.

3. Opportunities and challenges for MSW management

3.1 Opportunities

There are some identified advantages for MSW management in the MD that can be considered as opportunities for MSW management development as follows:

The low quality of the MSW management system can be a good opportunity to apply new suitable technologies for waste treatment and management in the region in the coming years.

There are various available fund sources from developed countries for developing countries, not only for research but also for investment projects in the field of MSW management development, so that it can be a great opportunity to invest in the development of MSW management and treatment. According to the Prime Minister decision (No. 1873/QĐ-TTg, 2010), there are plans for construction of

solid waste treatment in the Mekong Delta key economic zone with 1 central solid waste treatment zone and 5 provincial solid waste treatment zones.

The environmental protection law has become more effective presently. The national regulations and standards, governmental decrees, joint circular and local regulations and decisions are more and more strict in order to turn environmental protection into positive effect.

More and more qualified scientific staffs (master and PhD) have already been trained abroad and returned to work as key staffs in the provincial PC, DONRE, URENCO and in private consultant and design limited companies. These are contributing their know-how to the development of MSW management system in the MD. Joining the regional network for waste management is the best way for sharing practical experience, technical training and technology transfer activities.

3.2 Challenges

Available landfilling causes serious environmental problems that are related to leachate and air pollution emission control. In addition, current applied technologies for leachate treatment have been ineffective due to a huge amount of dense leachate, which is related to less clean water supply in the region. Moreover, green house gas emissions from landfills have also not been properly controlled and more land use for disposal is required, while land is more and more expensive due to urbanization in the region. Decision makers on waste technologies have not received adequate support from their staffs and less consultancy from local experts by lack of adequate assistance or available good technologies in the region.

Inflation and escalation of prices can limit many foreign investors who want to invest in MSW management in the region. For that reason, administrative procedure needs to be improved for promoting investment projects once approved. Climate change will be the most significant environmental impact in the future. Flood and inundation are increasing frequency; and magnitude, following sea water intrusion with high tide, contaminated soil, sea level rise, seasonal tropical storms increase as a result. According to the prediction of Vietnam's Initial National Communication to the UNFCCC (MONRE, 2003), the sea level increased in Vietnam with 5 cm within the past 30 years. It is expected to rise up to 9 cm in 2010; 33 cm in 2050; 45 cm in 2070; and 100 cm in 2100 (see Figure 2 for flood status and inundation map for one meter sea level rise). In this case, a vast area in the MD, estimated to 20-30%, will be affected. As a result, a large portion of the delta will be narrowed due to saline intrusion.

Saline intrusion enlargement due to sea level rise in the future will be the biggest concern for waste disposal as landfill. Integrated MSW management with other treatment options and solutions is expected to be developed soon.



Figure 2. Flood status and inundation map for one meter sea level rise (Source: Yamashita Akira, 2005; Carew - Reid Jeremy, 2007)

4. Future prospect of Integrated MSW management

As above discussed, an integrated MSW management is necessary to move from dumpsites to sustainable landfills. The basic elements of sustainable solid waste management system for Asian cities are depicted in Figure 3. This can possibly be applied to the Mekong Delta situation as an integrated MSW management. However, with an increasing of sea level and saline intrusion, some adjustments need to be done in order to adapt with the new situation in the MD. The specific suggestions are listed in Table 2 for each identified task or component.



Figure 3. Basic elements of sustainable MSW management system (Source: Visvanathan et. al, 2007)

Table 2. Problem	ms identification and spec	cific suggestions for M	SW management in the MD
Tasks /	Problems	Climate	Suggestion

1 asks /	1 I UDICIIIS	Chinate	Suggestion
components	and limitation	change effects	
MSW quantity	High and increasing		 Source segregation for recycling materials and inerts
and quality	High moisture con-		 Size reduction possibility
	tent		 Eliminating waste amount as low as possible
MSW compo-	High organic fraction		Composting
nents	in MSW		Anaerobic digestion
Landfill (open	Serious leachate and	Easily getting	• Sanitary landfill (bioreactor landfill) shift with leach-
dump sites)	air emissions	flooded	ate recirculation and LFG control.
	Impact to water	Saline intru-	• Reducing disposed waste (via composting, anaerobic
	sources	sion	digestion, pyrolysis, etc.)
Operating/closed	Leachate emissions	Flooding im-	Rehabilitation/reclaim
dumpsite	Air emissions (CH ₄ ,	pact	 Composting and remediation
	CO ₂)		Recyclable materials
			• Land reuse
Intermediate	Poor and less tech-	Less effect	• Increasing amount of MSW treatment by intermediate
treatment	nical and financial	from climate	• Upgrading and developing biological treatment for
	support for biological	change	MSW (e.g. composting)
	treatment of high		• Introducing thermal treatment and incineration (not
	organic MSW		suitable with high organic and moisture)
			 Introducing biogas/composting process for sludge of
			sewage and septic tanks
Recycling	Not being official	Less effect	 Turning it into an official industrial section
	Weak environmental		 Strictly environmental protection monitor
	emissions control	T 00	
Energy recovery	Weak and less ap-	Effect to cli-	• Energy recovery application encouragement for biogas
	plied technologies	mate change	• Energy savings
		possible	• Recovery of plastic waste as refuse derived fuel (RDF)
National encour-	Not enough		 Need a national financial and technical support
agement or sub-			 Capacity building support
sidy			
Public participa-	No good public par-		• Need to be developed
tion and envi-	ticipators		• Enhancing environmental education for children
ronmental educa-	weak environmental		(books, newspaper, television, etc.)
uon	protection awareness		

5. Conclusion

As MSW disposal problem prevails in Vietnam, especially in the MD, the paper focuses on the sustainable integrated MSW management due to climate change impacts in the coming years. Opportunities and potential challenges have been recognized for conducting an integrated MSW management system as a new approach. The open dump sites need to be shifted into bioreactor landfill together with integrated solutions for MSW management activities such as source separation, size reduction, waste elimination, recycling, composting, pyrolysis and incineration, national encouragement or subsidy, and public participation.

6. References

- [1] CIA 2010. The World Factbook. (https://www.cia.gov/library/publications/theworld-factbook/geos/vm.html, retrieved on 2011-11-27).
- [2] Nguyen, X.H., Le, H.V. 2011. Solid waste management in Mekong Delta. J. Viet. Env., 1(1): 29-35.
- [3] Nguyen, H.N. 2007. Flooding in Mekong River Delta Vietnam. UNDP. Human Development Report 2007/2008.
- [4] IPCC 2007. Climate change 2007: Impacts, adaption and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press. Cambridge, UK, 976 pp.
- [5] Nguyen, P.D., Nguyen, T.V. 2009. Status and

strategies on solid waste management in Ho Chi Minh City. Int. J. Environment and Waste Management 4(3/4): 412-421.

- [6] Sub-Institute of HydroMeteorology and Environment of South Vietnam 2010. Climate change in the Mekong Delta (Vietnam – Netherlands Mekong Delta Master Plan project report), Hochiminh, 2010.
- [7] Sub-Institute of HydroMeteorology and Environment of South Vietnam (SIHYMETE) 2010. Climate change in the Mekong Delta (Vietnam – Netherlands Mekong Delta Master Plan project report), Hochiminh, 2010.
- [8] No. 1873/QĐ-TTg 2010. Approval of the planning for construction of solid waste treatment in the Mekong Delta key economic zone up to 2020. Ha Noi (signed 11/10/2010).
- [9] MONRE 2003. Vietnam's Initial National Communication to the UNFCCC, Hanoi, Vietnam.
- [10] Yamashita, A. 2005. Zoning for risk assessment of water-related natural disasters in the Mekong Delta. Master thesis. Can Tho University.
- [11] Carew-Reid, J. 2007. Rapid Assessment of the Extent and Impact of Sea Level Rise in Viet Nam, Climate Change Discussion Paper 1, ICEM

 International Centre for Environmental Management, Brisbane, Australia.
- [12] Visvanathan, C., Kurian, J., Chiemchaisri, C., Zhou, G., Basnayake, B.F.A. 2007. Integrated Networking for Sustainable Solid Waste Management in Asia. Proceedings of the International Conference on Sustainable Solid Waste Management, 5 - 7 September 2007, Chennai, India. pp.27-33.