Original Article

Survey of Solid Waste and Wastewater Separate and Combined Management Strategies in Rural Areas of Iran

Mohammad Fahiminia[1], Mohsen Ansari[2], Shahram Nazari[3], ***Gharib Majidi[2]**, Vahideh Fahiminia[4], Simin Nasseri[5], Amir Hossein Mahvi[5], Ali Akbar Azimi[6], Naser Yousefi[2]

1- Department of Environmental Health Engineering, Research Center for Environmental Pollutants, Qom University of Medical Sciences, Qom, Iran
2- Department of Environmental Health Engineering, School of Public Health, Qom University of Medical Sciences, Qom, Iran
3- Department of Environmental Health Engineering, School of Khalkhal Medical, Ardabil University of Medical Sciences, Ardabil, Iran
4- Department of Environmental Health Engineering, School of Public Health, Kermanshah University of Medical Sciences, Kermanshah, Iran
5- Department of Environmental Health Engineering, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran
6- School of Environment, University of Tehran, Tehran, Iran

***gharibmajidi@gmail.com**

(Received: 19 Jun 2014; Revised: 3 Nov 2014; Accepted: 11 Dec 2014)

Abstract

Background and Purpose: Improper wastewater and solid waste management in rural areas could be a risk to human health and environment pollution. One percent of Iran's rural area is connected to the wastewater collection network. Solid waste management in rural areas of Iran is mainly consisted uncontrolled dumping and open burning. The aim of this study is prioritization of wastewater and solid waste separate and combined management strategies in rural areas of Iran.

Materials and Methods: This was a descriptive study. In this study, firstly were determined appropriate and conventional methods for wastewater and solid waste separate and combined management by using national and case studies. Then, using specified criteria and by applying a weighting system, prioritization was conducted and implementation strategies presented for wastewater and solid waste separate and combined management.

Results: The first priority for the collection and treatment, wastewater in rural areas are small-diameter gravity systems and preliminary treatment with complementary treatment by land, respectively. In order to the rural solid waste management, organic compost complementary systems were in first priority. In the wastewater and solid waste combined management, the first priority was compost and biogas production by combining anaerobic UASB reactor and Chinese biogas.

Conclusion: Considering for influence of various factors in selecting an appropriate method is very important in order to wastewater and solid waste separate and the combined management of a rural. Therefore, the accordance of presenting strategy with local conditions and facilities should be taken into consideration.

*[Fahiminia M, Ansari M, Nazari Sh, *Majidi Gh, Fahiminia V, Nasseri S, et al.* **Survey of Solid Waste and Wastewater Separate and Combined Management Strategies in Rural Areas of Iran**. *IJHS 2014; 2(4): 27-35] http://jhs.mazums.ac.ir*

***Key words*:** Solid waste, Wastewater, Management, Rural areas, Iran

1. Introduction

Wastewater management inadequately led to endangering the health of millions of people around the world caused by exposure to dangerous levels of microbial and chemical pollution (1). Lack of the sufficient sanitation leads to many diseases, including Ascariasis, diarrhea, hookworm, and bilharziasis. According to estimate of the World Health Organization, 2.1 million people die annually from diarrhea (2). Four percent of all mortality in the world due to water pollution by wastewater (3). In developing countries, <18% of rural communities have access to sanitation services (4). Rural solid waste management in developing countries mainly include, uncontrolled dumping and open burning (5-9). The most obvious environmental damage caused by solid waste related to beauty. Leachate of dumping sites can contaminate surface water and groundwater (10).

Iran, with an area of 1,628,554 km^2 has a population of 70,495,782 people. 31.54% of Iran's population live in rural areas. Present in about 18% of urban areas and 1% of rural areas have a wastewater collection network. 5000 rural communities have a population more than 200 households (approximately 1,000 people). 90% of the rural populations have access to safe drinking water in Iran (11,12). In Iran's rural areas, groundwater is the main source of water supply and discharge of wastewater is a major cause of groundwater pollution. Contaminated groundwater, can lead to outbreaks of waterborne disease (13).

According to the National Water and Wastewater Development Program, 60% of the urban population and 30% of the rural population should be have the wastewater collection network system and treatment wastewater until 1404 years (12).

Solid waste management in Iran's rural areas is the responsibility of Ministry of Interior. Dehyaris is ordered to the collection and disposal of solid waste in rural areas. In Iran, only 12% of rural areas are covered with the waste management system. Ordered elements of the solid waste management in Iran's rural areas system include the collection and land disposal. The Land disposal is higher as the dumping, open burning and rarely landfilling (14-16).

May provide the wastewater collection network and wastewater treatment plant separately for rural communities due to scattered locating, small-scale and complex geographic location, uneconomical and impractical (17,18). Wastewater of rural areas with low population can be treated by decentralize systems that are simpler and economical (19). These methods include septic tank, stabilization pond, wetland, and anaerobic biological treatment (18). The decentralized and semi-centralized natural treatment systems in compared to central technical systems, save energy and materials 76% and 83%, respectively (20).

Two key issues in the selection of treatment methods are affordability and appropriateness. Affordability refers to the economic situation of society whereas appropriateness refers to social and environmental conditions. In addition, the best strategy is a strategy that can be economically secure, environmentally sustainable, and socially acceptable (4). The aim of this study was prioritization of the wastewater and solid waste separate and combined management strategies in rural areas of Iran.

2. Materials and Methods

This was a descriptive study. In this study, first by using nationally and case studies was conducted in about rural wastewater and solid waste (11-15) and current situation of the country's rural areas, suggested strategies for wastewater collections, wastewater treatment, solid waste separated management and solid waste and wastewater combined management (Table 1).

Suggested strategies for collecting wastewater with the nine criteria (weight of 1-5) and the relevant sub-criteria (a score of 1-10) by designed questionnaire and accordance to views and analytical of the experts were weighted and the properties of each of the strategies and situation of each of rural were compared and prioritized ultimately (Table 2).

For prioritization of the wastewater treatment strategies in rural areas, as for high effectiveness of type of the treatment system from the weather conditions, groundwater levels and ground texture, the country's rural areas were categorized into four groups, first (Table 3).

Then, based on criteria, treatment strategies in each of the four categories were weighted and prioritized (Table 4).

Table 1. Suggested strategies for wastewater and solid waste separate and combined management

Type of suggested strategies	Suggested strategy
Suggested strategies for collecting wastewater in rural areas	Strategy 1: Pressure sewer system
	Strategy 2: Vacuum sewer system
	Strategy 3: Small diameter gravity
	Strategy 4: Simplified sewer system
Suggested strategies for wastewater treatment in rural areas	Strategy 1: Absorption wells
	Strategy 2: Preliminary treatment with complementary treatment by land
	Strategy 3: Stabilization pond and wetland (natural systems)
	Strategy 4: Reactor systems
Suggested strategies for separate waste management in rural areas	Strategy 1: Reduce the production, source separation, temporary storage, collection, transport, processing and recycling of dry waste valuable, organic waste biocompost and disposal
	Strategy 2: Reduced the production, source separation, temporary storage, collection, transport, processing and recycling of dry waste valuable, anaerobic digestion (biogas) and landfill
	Strategy 3: Reduce the production, source separation, temporary storage, collection, transport, processing and recycling of dry waste valuable and landfill
Suggested strategies for combined management of wastewater and solid waste in rural areas	Strategy 1: On-site aeration composting (Maltrum)
	Strategy 2: On-site aerobic composting with pit
	Strategy 3: On-site anaerobic composting with pit
	Strategy 4: compost and biogas production by combining anaerobic UASB reactor and Chinese biogas

Table 2. Criteria for wastewater collection systems with each other and compare their weights

Criteria	Weight
Need to mechanical and electrical equipments	5
Operation and maintenance problems	4
Administration problems	4
Impact on wastewater treatment system	3
Internal diameter of the pipe and piping depth	3
Need to build septic tanks and storage tanks in the network	2
Energy consumption rate	2
Infiltration and exfiltration rate	1
Need to build manhole	1

Table 3. Rural classification based on climate, groundwater levels, and land permeability

Group	Characteristics		
	Climate	Groundwater levels	Land permeability
1	Tans'-dry and dry desert	Low	Permeable
2	Semi-arid and the Mediterranean	Low	Permeable
3	Tans'-dry and dry desert	High	Not permeable
4	Semi-arid and the Mediterranean	High	Not permeable

Table 4. Criteria for compare of wastewater treatment systems in rural areas of the country and weight

Criteria	Weight	
	Dry weather	Semi-arid and the Mediterranean
Economic	10	5
Efficiency	6	6
Ability	3	3
Needs	2	4
Environmental and health	2	3
Reuse ability	2	1

In order to the prioritization of separate solid waste management strategies in rural areas, the suggested strategies with the criteria such as required land, energy, cost, environmental impacts, and the complexity of the each process, ease of implementation, public acceptance, and recovery rates were compared, and finally were prioritized. As well as to prioritize strategies of wastewater and solid waste combined management in rural areas, the suggested strategies with criteria such as the generation of energy, costs required (construction and operation), health and environmental impacts, process complexity of construction and operation and the amount of recovered material has been compared and finally were prioritized.

3. Results

Prioritization of the strategies of collection of wastewater in rural areas is presented in table 5. The first priority is a small diameter gravity system.

Prioritization of the strategies of wastewater treatment in the country's rural areas is shown in table 6. The first priority of wastewater treatment is preliminary treatment with complementary treatment by land.

Table 5. Prioritizing strategies for wastewater collection in rural areas of the country

Priority	Type of collection system	Point
Frist	Small diameter gravity	182
Second	Simplified sewer system	123
Third	Pressure sewer system	94
Fourth	Vacuum sewer system	86

Prioritization of different solid waste management strategies is presented in table 7. Organic compost complementary systems are the first priority.

Prioritization strategies of wastewater and solid waste combined management are shown in Table 8. In wastewater and solid waste combined management, first priority is compost and biogas production by combining anaerobic UASB reactor and Chinese biogas.

4. Discussion

One important component of the wastewater management, the collection and transporting it from place generation to the treatment plant. Less than 1% of the Iran's rural areas have a wastewater collection network. As referred above, up to the years of 1404, should be having 30% of the rural population as collection networks and the wastewater treatment. Based on study results, the first priority of wastewater collection methods in

Iran's rural areas is, the small diameter gravity system and simplified sewer system is the second priority. Application of two collection methods, pressure sewer system and vacuum sewer system as for its high costs and construction and operational problems in rural areas of Iran, have less priority. In Britain, Hungary, and Finland 98, 56 and 20 percent of rural households connects to the wastewater collection network, respectively (21). In China's rural areas, more than 97% of domestic wastewater discharge directly into the lake, river, soil or the sea and <1% of wastewater is treated (22). About half of the households in rural areas of Denmark discharge domestic wastewater to streams, lakes, or seas (23).

Table 6. Prioritizing strategies for wastewater treatment in rural areas of the country

Group	Priority	Type of system	Point
Frist	Frist	Absorption wells	186
	Second	Preliminary treatment with complementary treatment by land	168
	Third	Stabilization pond and wetland	150
	Fourth	Reactor systems	108
Second	Frist	Preliminary treatment with complementary treatment by land	161
	Second	Absorption wells	160
	Third	Stabilization pond and wetland	133
	Fourth	Reactor systems	122
Third and Fourth	Frist	Preliminary treatment with complementary treatment by land	161
	Second	Stabilization pond and wetland	133
	Third	Reactor systems	122

Table 7. Prioritizing strategies for solid waste management in rural areas of the country

Criteria	Strategy		
	Waste reduction, source separation, temporary storage, collection, recycling, organic compost and sanitary landfill	Waste reduction, source separation, temporary storage, collection, recycling, biogas and sanitary landfill	Waste reduction, source separation, temporary storage, collection, recycling and sanitary landfill
Land require	1	2	3
Energy production	2	1	3
Cost	2	3	1
Environmental impact	1	2	3
Facility and process complexity	2	3	1
Material recovery	2	1	3
Public acceptability and safety	1	2	3
Point	11	14	17
Priority	Frist	Second	Third

Table 8. Prioritization strategies of wastewater and solid waste combined management

Criteria	Strategy			
	Compost and biogas production by combining anaerobic UASB reactor and Chinese biogas	On-site aeration composting (Maltrum)	On-site anaerobic composting with pit	On-site aerobic composting with pit
Energy production	1	3	2	3
Cost	4	3	1	2
Health and environmental impact	1	2	4	3
Facility of construction and process operation	4	2	3	3
Material recovery	1	2	3	4
Point	11	12	13	15
Priority	Frist	Second	Third	Forth

Based on the study results, in the majority of rural communities, on-site and natural treatment strategies were in first priority and reactor systems were in the last priority. Application of the absorption wells for wastewater disposal in the third and fourth rural areas due to high groundwater levels and unsuitable permeability of the ground is not possible. In areas where land is available convenient and adequate, the stabilization pond system will be possible. In rural areas of Turkey, the wastewater management methods mainly include Septic tank, absorption wells, and package systems (24). In rural areas of Jordan, the method of sanitation is cesspool (25). Appropriate methods for wastewater management in Hungary's rural areas are usage of natural wastewater treatment systems, such as, pond systems, planting trees systems and aquatic plant systems (21). The study was performed by Sharafi et al. about the efficiency of stabilization ponds, artificial wetland, activated sludge with extended aeration and conventional activated sludge in removal parasites and protozoan cysts. The results revealed that the efficiency of natural systems to remove parasite eggs and protozoan cysts are better than mechanical systems (26). The study was conducted by Dong et al. about performance processed septic tanks, biological treatment units, artificial wetlands, stabilization ponds and activated sludge treatment units in rural areas of China. Determined that Septic tank is inefficient in the reduction of nutrients and pathogens. The results revealed that the performance of activated sludge processes and artificial wetland are better than stabilization ponds and low-energy biological facilities. In this study, artificial wetland was offered for dispersed rural's population (18).

Discharge of effluent from the septic tank into the aquatic environment is inappropriate due to high total suspended solids, biochemical oxygen demand, fecal coliform, total nitrogen and total phosphorus (27). The aerobic biological treatment units and membrane bioreactors, eliminate pollutants effectively, but the costs of operation and maintenance are high that not economical in developing countries (28,29). Artificial wetland and wastewater stabilization ponds are widely used for wastewater treatment in rural areas (20). Use of wetland depends on the weather conditions. From benefits of the wetlands can be noted to, high-efficiency pollutant removal, adaptability to changes in loading, ease of construction, operation and easy maintenance and low cost of operation (23,30). The Stabilization ponds operation and maintenance is easy and construction costs is low (31). The use of stabilization ponds can create problems in viewpoint of beauty and odor (32).

In suggested strategies for the separated management of solid waste in rural areas, waste reduction, source separation, temporary storage, collection, recycling, and sanitary landfill exist in all strategies. The results of this study revealed that composting systems are in first priority, and the producing of biogas is the second priority. Priority of recycling items in rural areas of Iran is degradable material (composting), plastic, paper, and metal (16). In a study that were performed by Abduli et al. in 21 rural areas in the Bushehr province, Iran, revealed that low-level technology composting due to the low cost of land, ease of access to labor and the low volume of biodegradable materials, in the priority (5). In a study by Jozi et al. in 22 Minab's rural areas were conducted, composting method was proposed for degradable solid waste management (33). Quality of compost produced from solid waste in the city of Babol, Iran, was assessed by Amouei et al. Quality fertilizer produced from mixed solid waste was at Class A standard of Environmental Protection America (34). Shah et al. suggested strategy of vermicompost to

solid waste management in six rural areas of India Tekanpur (6). In another study was conducted by Taboada-Gonzalez et al., in two rural areas in northern Mexico, biological digestion and composting was proposed for household solid waste management (7). In a study that was conducted by Lal et al. in rural areas of Rewa Province, India, reuse, source reduction, recycling and composting of household organic waste for rural solid waste management was proposed (9).

Prioritizing strategies of wastewater and solid waste combined management illustrated that strategy of compost and biogas production by combining anaerobic UASB reactor and Chinese biogas in first priority and the second priority is Maltrum strategy. The strategies, which energy recovery is not possible and the possibility of environmental contamination is high, having a lower priority.

Many factors involve in choosing the suitable strategy for the separate and combined management of wastewater and solid waste rural areas. Should be noted that the importance of the criteria are not the same for different projects and in each case, it is necessary to determine the coefficients of the importance of each to be selected. Since the coefficients are effective in selecting the best strategy, it is recommended that these coefficients according to the requirements, possibilities, and limitations, exact to determine. The results of this study could be used by experts as a guide in selecting the appropriate strategies for separate and combine management of wastewater and solid waste in rural areas.

Acknowledgement

Authors are grateful to the technical and instrumentation support of the Rural Water & Wastewater Company authorities of Qom province and Qom University of Medical Sciences.

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