Liquid waste management strategies for coastal areas

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Abstract Liquid waste management in coastal areas is a challenging issue, because recipe solutions applied so far have not met the expectations fully. Therefore decision-makers, planners, engineers as well as the inhabitants of these places are looking for a better approach that will adequately handle the problem and perform reliable solutions. It is the aim of this paper to review the recent situation of liquid waste management for coastal areas in general, and discuss it from the point of view of Turkey in particular.
A simple and applicable waste management strategy is also proposed in the paper and its merits are illustrated in a case study. Finally, anticipating the wide applications of such systems in coastal establishments, some recommendations are forwarded.

Keywords Centralised treatment system; decentralised treatment system; liquid waste management; on-site treatment; septage; septic tank

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Introduction

Today, half of the world's population lives in coastal areas and it is estimated that it will reach to about 75% by the year 2020. The ratio will obviously be much higher in countries where tourist facilities and recreational activities have importance. Turkey, having 8,250 kilometres of coastline, is such a typical country, where many small or large-scale establishments are spread along the coastline. Among these establishments, some are relatively big cities and trying to cope with environmental problems by means of high-cost and high-capacity infrastructure systems, namely long sewerage and centralized treatment plants. These are generally funded by international finance agencies (such as World Bank), and the construction phases together with bureaucratic procedures are accomplished at a slow pace. This results in continuation of contamination of the environment and thus increases the related prevailing problems especially in developing countries.

Many relatively small communities such as individual residences, clusters of homes, and resort areas located on the coastal zone have been suffering from the lack of appropriate sewerage and waste disposal systems due to the economic as well as geographical reasons. Until recently, the popular approach to handling wastewater has been to collect in sewers and treat it at a central plant. This approach has been preferred because many simple methods such as on-site systems have been failing. However, experiences have shown that this approach may be inappropriate in small communities, because it is difficult to manage one large system rather than small on-site solutions, and it is not less costly per user and does not provide extra capacity in areas that are just developing (EPA, 1987). Hence, alternative wastewater collection and treatment options, namely decentralized systems, have been developed for such places where the community can not afford the cost of a conventional wastewater management system, and/or where the residential density is sparse. Therefore, the decentralized wastewater management (DWM) approach has been of great importance to the future management of environmental issues of coastal residential areas for the last few decades. Such solutions are particularly important and so suggested for the "transition periods" that may be defined as "the time between the appearance of environmental problems and the realization of all required modern technical measures" (Akyarlı, 1998). This period may sometimes last a few decades and the capacity of ongoing investments generally becomes insufficient. On the other hand, coastal establishments have their own special characteristics, such as significant changes in population and the amount of waste generation. Therefore, those technical characteristics must be contemplated in the application of the DWM approach and local and regional environmental strategies should be developed.

This paper focuses on liquid waste management strategies in coastal areas and examines the trade-off between the longer collection systems and relatively big treatment plants (Centralised Wastewater Management approach-CWM) versus septic tank applications and transportation and rehabilitation of sludges in local-constructed simple plants (DWM). The prevailing laws and regulations in Turkey, their failings and restrictions are also introduced. Instead of enforcement of law-based strict applications, the locally planned and managed systems are proposed and their positive effects over the environmental protection activities are emphasized. Finally, a case study accomplished for a typical establishment, namely the city of Muğla, is demonstrated and related recommendations are proposed.

Liquid waste management in coastal establishments

Characteristics of coastal establishments in Turkey

Coastal establishments in Turkey generally reflect a resort character and thus their population varies significantly throughout the year. There are numerous hotels, motels, summer houses (or so called second houses), holiday villages etc. along the coastal zones of the country. During the winter period, almost nobody lives in these second houses and most of the hotels are closed to be repaired(!). Some hotels may be partially full on the weekends, and during the national holidays. At the end of May the activities and population in such places start to increase, and by the beginning of June, when the schools are closed, people (families) move to their second houses. This sudden change happens in a week, and the activities reach their climax in July and August. The going-back process is relatively slow and starts in September and is completed by the end of November; then quiescent conditions govern these places.

This turnover directly affects the amount of waste generation and wastewater discharges; i.e., in the winter period the amount of wastewater is relatively low, whereas in high season (summer) or high periods (national holidays) the wastewater flow rate increases two or three fold, even in some places and periods it becomes ten or twenty times greater than the average winter flowrate. Apart from the seasonal or monthly variation of wastewater flow rate, there is a significant weekly variation, i.e., on weekdays versus weekends. Finally daily variations depending on the life style of summer periods, is the factor that should also be considered when any infrastructure investment is designed.

Therefore, planners and engineers suffer a lot from designing and operating the centralized treatment systems including wastewater collection. Because when sewers (and also treatment plants) are constructed considering winter flow rates, they will not meet the summer time demands. On the contrary, infrastructures implemented for summer period conditions, then become over-designed for winter time and significant operational problems occur. Also cost-effectiveness of such investments in coastal towns is relatively lower than those of typical (regular) establishments.

Prevailing legal and technical conditions

In spite of the facts given in the previous section (i.e. significant monthly, weekly, daily, etc. variations in the amount of wastewater), the general trend is to implement centralised wastewater collection and treatment systems. Because this is an easy recipe which most of the authorities (generally municipalities) are used to applying. If they can provide any money from any source, they first just make a tender, comprised of excavation of the trench, and laying the pipes in which sewage is conveyed to the point of discharge or treatment or disposal. The wastewater treatment plant is the second issue generally tendered by the termination of the sewage collection system. The time lag between the two is sometimes so long, that severe environmental damage at the discharge point of the sewerage takes place. Therefore, the authors of this paper highly recommend to initiate the treatment plant construction first, and progressively to connect the sewers to the plant from the end (downstream) to the top (upstream). This actually is a very trivial know-how, however, this fact is frequently ignored. The treatment systems are usually based on typical biological processes, designed for maximum flow rate, and comprise pre-treatment (bar racks – grit chamber – primary sedimentation tank), secondary treatment (generally activated sludge, aeration tank – final sedimentation tank), and disinfection (chlorination chamber) units. The collection system includes long sewers that pass through the sparse establishments and convey wastewater towards the coast, and a main interceptor located parallel to the coastline which receives wastewater coming from secondary sewers and ends at the wastewater treatment plant. Generally the main pipe is constructed under the groundwater table so generally there is a risk of seawater infiltration. The success of these systems needs some prerequirements such as good engineering services, skilled personnel, auxiliary equipment, etc. in order to be operated effectively. Many decision-makers ignore these requirements, as well as the cost-effectiveness of such solutions, and offer them for many establishments.

The establishments discussed in this paper are small towns and municipalities as far as their official populations are concerned. In other words, the central government in Turkey classifies the establishments according to their populations that are determined by periodical censuses, which are carried out every five years during the winter. Therefore coastal establishments are always counted when their population is low, thus government considers them as low-population density areas, which means they receive relatively less governmental support than crowded cities due to their low theoretical population. This fact is one of the controversial issues for coastal establishments and it has some social, technical and legal implications.

On the other hand, the wastewater discharge limitations in Turkey are directed by Water Quality Control Regulations (Official Gazette, 1988). This regulation undertakes the pollution problem in a categoric way and enforces the construction of wastewater treatment plants for all residential areas by ignoring their specific characteristics. A table that reveals fixed discharge standards for all type of residences and for coastal establishments has very tight and inflexible limitations. It is clear that such a categorical approach is not a very applicable regulation. Therefore most of the places violate the laws, that leads to charging fines first, and waiving or not processing them later. To this end, reviewing of regulations by considering decentralized systems is strongly recommended to government by many experts, engineers, non-governmental organizations, etc., and the modification of legal aspects has been under process recently in Turkey. Hence, a consensus about application of the LWM strategies for such establishments discussed above was agreed in the Fourth National Environmental Assembly held in November 2000, in Turkey. It encourages the development of on-site waste management facilities under the umbrella of LWM master plans and implementation of new laws and regulations that enable the use and rehabilitation of existing septic tanks, and allows the diversion of funds to the realisation of relatively long term ultimate solutions. In the assembly the "transition period" concept was also officially recognized and the controlled use of septic tanks was approved of and recommended.

Basic approaches for liquid waste management

Centralized wastewater management systems

In the areas where the population density is relatively high and stable, the conventional sewers combined with a centralized treatment facility may be the most appropriate solution. Here, it should be noted that two key words, *high* and *stable* population density characteristics should be satisfied simultaneously. Conventional sewers are costly and require close engineering inspection during the construction as well as operation. They convey wastewater to a treatment plant, which is designed to fulfill the discharge standards. There are many types of treatment plants available. The right one for an establishment depends on how strict standards for wastewater discharge are, how much land is available and the existing technology for maintenance and skilled personnel for operation. Therefore it should be noted here that the selection of the treatment plant is not an easy task and the decision-makers should consult well-experienced professional engineers. The success of the complete system depends on both proper planning and careful operation and maintenance. In fact, centralized wastewater management is a very broad issue, and since this paper focuses on decentralized, on-site systems, it will no longer be discussed here, just the definitions and basic principles are pointed out.

Decentralized wastewater management systems

Wastewater from individual dwellings and other community facilities in unsewered locations is usually managed by on-site treatment and disposal systems. This may be called a decentralized wastewater management system and it may comprise of wastewater collection, wastewater pre-treatment, wastewater treatment, effluent reuse or disposal, and biosolids and septage management (Crites and Tchobanoglous, 1998). It should be noted that not every DWM system would necessarily incorporate all of those elements. Although the components of the DWM may be interpreted as the same as for large centralized systems, the difference is in the application of the technology. For example, the objective of wastewater pre-treatment is to remove solids, oil and grease and other floatable and settleable materials so that the remaining wastewater can be treated effectively. Here, the use of individual septic tanks at the point of origin can be considered an integral part of DWM, because it manages the solids separately from the septic tank effluent.

A number of new technologies have been introduced for small treatment systems that have made it possible to produce an effluent of the same quality or even better, as compared to the large treatment plants. Among the variety of on-site systems, in this paper, the most common and simplest system, consisting of a septic tank and septage treatment is emphasized. Here, the important point is the proper installation and the operation of the septic tank system. Because if good plumbing and draining fixtures are not installed, problems such as surface ponding, ground water contamination, foul odour, etc. may occur. Successful application of septic tanks can be achieved provided that satisfactory land and drainage field and soil conditions prevail. In principle, septic tanks should be watertight, comprise of a few compartments that receive the wastewater from different sources, and equipped with perforated drainage pipes located in a permeable filter (stone) layer which enable the drainage of the supernatant. There is a mal-application in Turkey that without the drainage pipes, only the tank is constructed with un-mortared stone that permits the percolation of wastewater through the spaces of the tank wall. This application increases the risk of ground water contamination and rapid clogging of the pores that eventually leads to the filling of the tank quickly causing ponding. In fact, a septic tank system should never be underestimated, and should be considered as a whole from collection until the ultimate disposal of sludge. The tank itself acts as a long-term storage for solids in the wastewater and buffers the discharges and provides effective partial treatment. The supernatant in the tank is conveyed by small diameter perforated pipes and released as subsurface disposal for final treatment. Solids retained in the tank are evacuated by the trucks at the end of each season or when required, and should be disposed properly. One of the disposal approaches which is recommended by the authors of this paper is the lime stabilization (Akyarli and Ozture, 1996; Alpaslan and Dolgen, 1998). This method will be explained in detailed below and a case study introduced in the following section.

Proposed solution

The problems associated with septic tank application are two-fold, namely, capacity inadequateness and the fate of the septage (or sludge) that settles out of wastewater in the tank and is removed once or twice per year. The former problem can be solved by better estimation of the wastewater amount, suitable installation of plumbing and providing good infiltration capacity. The solids removed from wastewater require stabilization followed by disposal or reuse. Septage, the material pumped out of septic tanks also requires further stabilization prior to disposal or reuse. As it is very well known, particularly in USA, and also as it is well documented by EPA, lime stabilization of septic waste is a low capital cost and simple technology.

The septage management may be the *centralized* part of the proposed decentralized system. This is achieved by implementing a central septage treatment unit that may be out of the city and far from sight. In fact, the proposed unit has no negative implication to the environment and does not cause any nuisance conditions, however, since septage is transported by trucks, it is much better to locate it in such an area in order not to attract adverse public awareness and opposition. The septage treatment is, in fact, a chemical treatment process where lime is added into the septage and the pH is increased to above 12, and kept there for about half an hour. This process destroys all harmful microorganisms, and inhibits the bacterial activity. Therefore, the end product has no odour and no pathogenic risk, however it is rich in terms of nutrients; hence, it can be used on land as conditioner and fertilizer.

A case study: city of Muğla

The recent lime stabilization system has been in operation in the city of Muğla (which is a city in western Turkey having most famous holiday resorts like Marmaris, Bodrum and Fethiye as her satellite towns located along the Mediterranean coast) for about six months. This system can be considered as the unique example of the septage management concept in Turkey. Although there are some other settlements, either coastal or inland, appropriate for the application of DWM systems, here, it should be noted that the significant difference of Muğla from other potential establishments is the open-minded and science-oriented decision-makers, who comprise key authorities of both the local and central governments with special support from the mayor himself and the Director of Environment.

There is a central facility that accepts wastewater (being pumped out from septic tanks and transported by trucks) via holding tanks, and then treats it by mixing with an adequate amount of lime in a reactor to increase pH to 12 for at least 30 minutes. The only mechanical equipment is a simple diesel-powered pump that transports wastewater from holding tanks to the reactor, and also provides its circulation in the reactor during the mixing phase. The outlet of the system is serial lagoons the first of which behaves as a settlement basin, and the others act as maturation and polishing ponds. The water flows between those successive ponds by gravity, because each lagoon has been located at a lower elevation than the previous one.

The stabilized sludge is periodically taken from the bottom of the first lagoon, and is applied to agricultural areas and forest as fertilizers. According to the field trials conducted by the members of Mugla University and Regional Directorate of Ministry of Forestry, the results are very promising which encourages the authors for the future of similar applications at several potential places in Turkey.

Recommendations and conclusions

Coastal establishments are both small and large towns depending on the period of tourism. Coping with the wastewater problems of such areas is an emerging and difficult issue that should be solved. As discussed earlier, if the town is considered with its peak population during the high season, and thus if a typical centralized solution for wastewater management is dictated, then the result will likely end in vain, and a lot of money will be wasted. This is because centralized wastewater management approaches require continuous operation i.e. 365 days per year, whereas the waste load originating from coastal establishments is intermittent and available only during the tourism period. This fact creates operational problems in collection systems as well as in treatment plants during the winter (low) time. In addition, start up of such plants at the beginning of every season and operating them under significant varying flow conditions is another troublesome task. Therefore, instead of centralized systems, so called decentralized approaches are proposed for coastal establishments. One of the basic advantages of DWM is to reduce the cost of treatment by retaining water and solids near their point of origin and to require very easy operation that can easily be performed by any person or organization. Plus the protection of public health as well as the receiving environment are other benefits. This advantage makes the DWM system one of the powerful tools of the sustainable development efforts for the developing countries.

When the density of the area increases, the application of DWM systems may still be valid, if the implementation and operation responsibility of DWM systems are given to a public or private agency in order to ensure the proper periodic inspections and necessary maintenance. The availability of a management agency will also allow sludge disposal and such a task could be undertaken as a part of the organization's ongoing duties and responsibilities. This is one of the imperative issues when DWM systems are used for relatively high densely populated areas.

It is not necessary to consider the septage alternative as the ultimate solution for the wastewater management of a coastal establishment. As stated previously, this approach can also be applied for transition periods that may last more than a few years, even decades. Technical achievement of this option will bring several opportunities to decision-makers to increase their fund raising power. In this way, the existing potential of septic tanks can be used until the completion of sewage systems.

The application of DWM systems, particularly the use of septic tanks, even in a controlled manner, may cause the emerging of conflicts due to the very tight and inflexible rules and regulations. Because generally the effluent characteristics of septic tanks do not meet the standards, and thus authorities generally do not permit their legal application. If this controversial issue can be solved legally, new logical schemes, which facilitate transfer of individual expenditures to finance the sewerage system can be adopted, otherwise it promotes temporary investments, which leads to the waste of money (Akyarli, 1998).

It may be another option to integrate a lime stabilization unit in a chemical treatment system by utilizing some already existing facilities like lime storage silos and lime dosage bunkers etc. On the other hand, the chemical treatment alternative is offered as one of the most appropriate wastewater management technologies when it is associated with marine outfall systems (Dolgen and Alpaslan, 1997; Dolgen *et al*., 2000). Because in some applications of centralized systems, wastewater generated from coastal establishments has been disposed into the marine environment untreated, provided that required dilution conditions were maintained. However, the increasing public concern and global sensitivity over ecology have enforced the implementation of treatment units before discharge of wastewater into the sea. Here, the modification of lime stabilization facilities to the coagulation-flocculation and sedimentation units has strongly been recommended for marine outfalls prior to discharge. Finally, the economic advantage of lime stabilization to anaerobic and aerobic digestion systems should also be emphasized (NLA, 1998).

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