Contents lists available at ScienceDirect

Asian Pacific Journal of Tropical Biomedicine

journal homepage:www.elsevier.com/locate/apjtb

Document heading doi:10.1016/S2221-1691(11)60035-X 

# Prospects of effective microorganisms technology in wastes treatment in Egypt

Emad A Shalaby*

*Biochemistry Department, Faculty of Agriculture, Cairo University, Giza, Egypt, 12613*

ARTICLE INFO

*Article history:*
Received 15 January 2011
Received in revised form 18 February 2011
Accepted 10 March 2011
Available online 30 March 2011

*Keywords:*
Effective microorganisms
Wastes treatment
Egypt
Sludge dewatering
Wastewater
Pollutant
Organic matter
Decomposition
Bacteria
Contamination

ABSTRACT

Sludge dewatering and treatment may cost as much as the wastewater treatment. Usually large proportion of the pollutants in wastewater is organic. They are attacked by saprophytic microorganisms, *i.e.* organisms that feed upon dead organic matter. Activity of organisms causes decomposition of organic matter and destroys them, where the bacteria convert the organic matter or other constituents in the wastewater to new cells, water, gases and other products. Demolition activities, including renovation/remodeling works and complete or selective removal/demolishing of existing structures either by man-made processes or by natural disasters, create an extensive amount of wastes. These demolition wastes are characterized as heterogeneous mixtures of building materials that are usually contaminated with chemicals and dirt. In developing countries, it is estimated that demolition wastes comprise 20% to 30% of the total annual solid wastes. In Egypt, the daily quantity of construction and demolition (C&D) waste has been estimated as 10 000 tones. That is equivalent to one third of the total daily municipal solid wastes generated per day in Egypt. The zabbaliin have since expanded their activities and now take the waste they collect back to their garbage villages where it is sorted into recyclable components: paper, plastics, rags, glass, metal and food. The food waste is fed to pigs and the other items are sold to recycling centers. This paper summarizes the wastewater and solid wastes management in Egypt now and future.

## 1. Introduction

Environmental management, wastes recycling, treatment and disposal, pollution control and prevention and wastewater reuse became the most important issues and in the top of the global agenda[1]. Waste water usually can be processed for disposal or recycling by one or more steps. The first step, usually, is the preliminary and primary treatment, which is physico-chemical treatment. Because of the objection properties of the effluent, the secondary treatment, which is biological treatment, is employed. The operation involves the biological degradation of organics, both dissolved or suspended materials by microorganisms under controlled conditions. Biological treatment can be accomplished in a number of ways, but the basic characteristic of the system is the use of mixed microbial culture: bacteria, fungi and / or algae, for the conversion of pollutants. In most cases, organic materials are converted to oxidized products, mostly carbon dioxide and new microbial cells (the sludge). The organic materials serve as an energy and carbon sources for cell growth[2].

A major problem facing municipalities throughout the world is the treatment, disposal and/or recycling of sewage sludge. Generally, sludge from municipal waste mainly consists of biodegradable organic materials with a significant amount of inorganic matter[3]. However, sludge exhibits wide variations in the physical, chemical and biological properties[4]. At the present time, there are a number of methods being used to dispose of sewage sludge from disposal to landfill for land application. Although there are many methods used, there are numerous concerns raised regarding the presence of constituents including heavy metals, pathogens and other toxic substances. This requires the selection of the correct disposal method focusing on efficient and environmentally safe disposal.

*Corresponding author: Dr. Emad Shalaby, Ph.D Biochemistry, Biochemistry Department, Faculty of Agriculture, Cairo University, Giza, 12613, Egypt.
Tel: +2 010 120 3313
Fax: +2 3774 2600
E-mail: dremad2009@yahoo.com, emad2e0m0a1d@yahoo.com
Foundation Project: Supported by a grant from Sanko Company for EM Production and its products; and by a grant from JICA Agency, OIC, Okinawa, Japan.

New technologies are being produced to assist in the treatment and disposal of sewage sludge, conforming to strict environmental regulations. One of these new technologies being proposed is the use of effective microorganisms (EM). The technology of EM was developed during the 1970's at the University of Ryukyus, Okinawa, Japan[5]. Studies have suggested that EM may have a number of applications, including agriculture, livestock, gardening and landscaping, composting, bioremediation, cleaning septic tanks, algal control and household uses[6].

EM is a mixture of groups of organisms that has a reviving action on humans, animals, and the natural environment[7, 8] and has also been described as a multi-culture of coexisting anaerobic and aerobic beneficial microorganisms. The main species involved in EM include: Lactic acid bacteria: *Lactobacillus plantarum*, *Lactobacillus casei*, *Streptoccus lactis*; Photosynthetic bacteria: *Rhodopseudomonas palustrus*, *Rhodobacter spaeroides*; Yeasts: *Saccharomyces cerevisiae*, *Candida utilis*; Actinomycetes: *Streptomyces albus*, *Streptomyces griseus*.

The basis for using these EM species of microorganisms is that they contain various organic acids due to the presence of lactic acid bacteria, which secrete organic acids, enzymes, antioxidants, and metallic chelates[9,10]. The creation of an antioxidant environment by EM assists in the enhancement of the solid-liquid separation, which is the foundation for cleaning water[7]. One of the major benefits of the use of EM is the reduction in sludge volume. Theoretically, the beneficial organisms present in EM should decompose the organic matter by converting it to carbon dioxide ($CO_2$), methane ($CH_4$) or use it for growth and reproduction. Studies have suggested that this is the case for both wastewater treatment plants and also septic tanks. Freitag[11] suggests that introducing EM into the anaerobic treatment facilities help to reduce the unpleasant by-products of this decomposition and also reduce the production of residual sludge. These factors tend to suggest that theoretically EM should assist in the treatment of wastewater by improving the quality of water discharged and reducing the volume of sewage sludge produced.

EM is eco-friendly, safe and organic. The EM fermented garbage is supplemented with useful microorganisms which makes the compost imminently suitable for agricultural use. EM is effective in all conditions. The turning process requires 20 to 22 days with higher C: N ratio due to presence of microbes. Just spraying on garbage heap is sufficient. With easy application, EM is safe for human health. It can treat the leachate coming out form the garbage as well, and remove the foul smell form decomposed garbage. Menace of flies and mosquitoes is suppressed to the minimal by application of this technology. EM technology is not only environmental friendly but goes a step further to actually protect the environment. It suppresses harmful gases generated form garbage, as per the Pollution Control Board (PCB) norms. It is very economical. EM provides healthy environment to the workers. All these mean lower cost of operations, easy application and at the same time protection of the environment[7].

## 2. Wastes management in Egypt

The sludge disposed during the various water treatment processes can be a major concern for water treatment plants. Most of the water treatment plants in Egypt discharges the sludge into the river Nile without treatment. The discharging of sludge into water body leads to accumulative rise of aluminum concentrations in water, aquatic organisms, and human bodies. Some researchers have linked aluminum's contributory influence to occurrence of Alzheimer's, children mental retardation, and the common effects of heavy metals accumulation[12]. Consequently, stringent standards of effluent discharge are coming into effect, and thus proper management of the sludge becomes inevitable. The use of water treatment sludge in various industrial and commercial manufacturing processes has been reported in UK, USA, Taiwan and other parts of the world. Successful pilot and full-scale trials have been undertaken in brick manufacture, cement manufacture, commercial land application. The mineralogical composition of the "water treatment sludge" is particularly close to that of clay and shale. This fact encourages the use of water treatment sludge in brick manufacture. Several trials have been reported in this purpose. Research carried out in the UK assessed the potential of incorporating aluminum and ferric coagulant sludge in various manufacturing processes including clay brick making. A mixture consists of about 10 percent of the water treatment sludge and sewage sludge, incinerated ash was added to about 90 percent of natural clay to produce the brick[3]. It is also investigated the incorporating of two waste materials in brick manufacturing. The study used waterworks sludge and the incinerated sewage sludge ash as partial replacements for traditional brick-making raw materials at a 5% replacement level.

About 60 000 000 tones of hazardous waste are produced annually in Egypt, with adverse consequences for the environment and human health. No infrastructure capable of proper disposal exists in Egypt. For example, there is only one disposal site for storage of hazardous industrial wastes, and dangerous wastes are generally deposited together with non-hazardous wastes. The Egyptian legal framework for hazardous wastes and waste management shows a few weak points. The present regulations, those of environmental law no. 4/94, are not properly enforced.

### *2.1. Wastewater treatment in Egypt*

In Egypt, the domestic wastewater in the rural areas is concentrated with a chemical oxygen demand (COD) as high as 1100 mg/L, which is almost two times of that in the urban areas[13]. El-sherbiney *et al*[14] determined the maximum aerobic biodegradability of the Egyptian domestic wastewater. They found that the minimum aerobic effluent COD concentration of rural areas was almost similar to the Egyptian effluent standards for COD, while the minimum aerobic effluent COD concentration of urban areas was significantly lower than that of the Egyptian effluent standards for COD. Ibrahim[15] evaluated the applied different technologies for domestic wastewater treatment in rural areas of Egypt. He also found that the effluent of these systems did not comply with Egyptian effluent standards for COD.

Problems of contamination resulting from organo-phosphorus (OPs) and wastewater from pesticide factories in Egypt have become obvious. These pesticides are highly toxic to fish and other aquatic invertebrates. In the environment, pesticides are exposed to various degradative forces. Biotic degradation, or metabolic processes, is known to play a vital role in this respect. They contribute not only to the disappearance of the original pesticides, but also change their physicochemical properties, and thus affect their transport and distribution behavior among various compartments in the environments. Dimethoate one of this major group that has an insecticidal efficiency for killing a wide range of insects, including aphids, thrips, planthoppers and whiteflies systemically and on contact [16]. This compound acts by interfering with the activities of cholinesterase (an essential enzyme for the proper working of the nervous systems of both humans and insects and is possibly carcinogenic). Because dimethoate is highly soluble in water and it adsorbs only very weakly to soil particles. Therefore, it is neither expected to adsorb to sediments or suspended particles, nor to bioaccumulate in aquatic organisms. Moreover, it undergoes rapid degradation in the environment and in sewage treatment plants. It is subject to significant hydrolysis, especially in alkaline waters. Being carbamate group of organophosphate, dimethoate is little less amenable to degradation as compared to other well studied organophosphates. The pH, temperature and the type of medium are important factors affecting the stability of dimethoate in water. The degradation of dimethoate depended mainly on the alkylation of the medium rather than the time of storage. Different pathways of OPs decomposition such as hydrolysis, photolytic oxidation, microbial transformations and other biological processes have been reported[17]. The earlier metabolic studies on pesticides helped to develop a new approach to the detoxification of pesticides using cell-free enzymes from adapted microorganisms to resolve problems related to whole-cell metabolism of pesticides[18]. The first report on bacterial utilization of dimethoate was reported by Liu *et al*[18]. They isolated a strain of *Pseudomonas stutzeri* from water that was obtained in fields with frequent application of OPs. 71.82% degradation was reported at 350 ℃ with shaking for 72 hrs. Thus, microbial degradation by fungi and or bacteria is the means of disappearance of dimethoate from water as it is used as source of 'C' and 'energy' or source of 'P'. The interest in the concept of EM began to introduce this EM technology that was developed by Higa & Chinen[7] at the University of Ryukyus, Okinawa, Japan. This technology includes three principal types of organisms commonly found in all ecosystems, namely acid bacteria, yeast, lactic actinomyces, photosynthetic bacteria and other microoganisms as yeast fungi and algae. Thus, this is the first manuscript that deals with such technology and it may be possible to make the best use of its advantage to remediate OPs from water. Moreover, Abdel-Megeed and El-Nakieb[19] evaluates the efficiency of EM on the degradation of dimethoate from contaminated water Figure 1 and suggests their role in the bioremediation of other pesticides contaminated water.

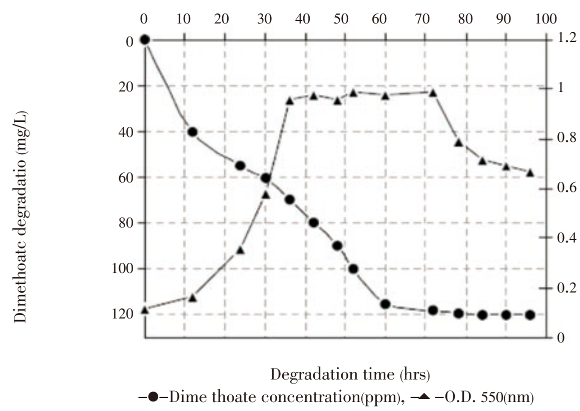


**Figure 1.** Growth of the EM in dimethoatc as a sole of carbon and energy source.

The industrial wastewater (WW) of potato-chips factory in Egypt is characterized by its high biological oxygen demand (BOD) and COD, in addition to a medium content of oil & grease (O&G), total dissolved slats (TDS) and total suspended solids (TSS). A new technique for wastewater treatment has been applied using bio-mixture of selected strains of *Aspergillus terreus* (*A. terreus*) or *Rhizopus sexualis* (*R. sexualis*) in addition to the natural flora of sawdust (SD-Biomix) in the form of mobile micro-carrier in activated sludge system. Different kinds of composted sawdust were used as a microbial carrier, support and source of nutrients and enzymes to enhance the wastewater treatment process, and to improve the quality of treated wastewater and resulting sludge. The parameters of treated wastewater in terms of BOD, COD, O&G, TDS and TSS were greatly improved by 85.0%, 79.0%, 82.7%, 74.6% and 87.7% respectively, in relation to the retention time and kind of tested materials. The 14 days microbial-treated (composted) sawdust by A. terreus, or R. sexualis as SD-Biomix exhibited the highest enzymes contents and was the most efficient materials for the wastewater treatment

**Table 1**

Data of enzymatic assays in 0.1 mg or 0.1 mL of the tested materials after 14 days of incubation at 25 ℃.

| Test material | Mean diameter of clearing zone(mm) | | | |
|---|---|---|---|---|
| | α -Amylase | Protease | Lipase | Cellulase |
| Municipal sludge | 0.0 | 0.0 | 0.0 | 11.5 |
| Non-composted sawdust | 0.5 | 0.0 | 0.0 | 0.5 |
| Culture filtered of *A. terreus* | 10.5 | 10.5 | 1.5 | 1.0 |
| Culture filtered of *R. sexualis* | 11.5 | 10.5 | 0.0 | 0.5 |
| 14-days composted sawdust by natural microflora and Potato-wastewater | 10.5 | 10.5 | 2.5 | 27.0 |
| 14-days composted sawdust y natural microflora and Potato-wastewater plus *A. terreus* | 32.0 | 13.0 | 10.5 | 45.0 |
| 14-days composted sawdust by natural microflora and Potato-wastewater plus *R. sexualis* | 27.5 | 11.5 | 5.0 | 35.5 |

**Table 2**

The wastewater parameters (mg/L) of potato-chips factor after the brological treatment using the commercial brosolution(0.1%) as mobile biomixture(SD-Biomix) for 8 hr under aerobic conditions at 25℃.

| Parameter | Commercial biosolution | | Test materials | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C157 | EM | Municipal sludge | Non.com. sawdust | Culture filtered *A. terreus* | Culture filtered *R. sexualis* | SD. Biomix | SD. Biomix plus *A. terreus* | SD. Biomix plus *R. sexualis* |
| pH | 8.1 | 7.6 | 8.5 | 8.5 | 6.0 | 5.7 | 6.8 | 6.5 | 7.1 |
| BOD | 847 | 820 | 800 | 1 870 | 390 | 420 | 650 | 300 | 270 |
| COD | 975 | 987 | 720 | 2 550 | 710 | 700 | 635 | 510 | 440 |
| TSS | 710 | 723 | 750 | 2 190 | 510 | 490 | 490 | 270 | 310 |
| TDS | 1 430 | 1 000 | 895 | 960 | 600 | 650 | 560 | 470 | 510 |
| O&G | 34 | 30 | 54 | 62 | 42 | 50 | 40 | 19 | 22 |

process in comparison with commercial biomixture products *e.g* C157 and EM solution (Table 1 and 2). Furthermore, the retention time of the treatment process could be reduced to 4 hr only. Finally, the resulting sludge(s) of (SD-Biomix) was easy to separate (in 5-10 min) from wastewater. The sludge, according the chemical analysis, can be safely used in agriculture as an organic fertilizer and soil conditioner. In addition, different kinds of resulting sludge have been tested as biosorbents and exhibited high ability to remove chromium (89.1%-99.3%), nickel (84.3%-98.0%) and zinc (85.6%-97.7%) from the heavy industrial wastewater. Data indicated the possibility of magnifying the introduced (SD-Biomix) as a new technique for the treatment of wastewater and as new trend for wastes management and pollution prevention and could be applied in Kingdom of Saudi Arabia (KSA) as one of advanced biotechnologies to solve many of environmental problems in KSA[20].

### *2.2. Solid wastes treatment in Egypt*

Proper waste collection and sanitary waste disposal have become very important issues for city management and represent a substantial work for municipalities. At the same time, waste generation rates and composition are changing with changes in population as well as composition patterns[21]. Leading to the fact that creating a proper waste management system or improving the existing one need extensive field studies with multi-disciplinary approach (Socio-economic and technical approaches).

In Egypt, the problem of solid waste management (SWM) has been aggravating everywhere. Its negative manifestations as well as its direct and indirect harmful, even serious, consequences on public health[22], environment and national economy (particularly as related to manpower and tourism) are becoming quite apparent and acute. Recently, the problem has taken a newly favorable dimension with the rising public awareness and state attention within the general progressive national movement. In effect, the problem has been given high priority that culminated political commitment at the highest levels of the government. A decisive confrontation towards a complete eradication of this pervasive problem, based on a well founded scientifically planned approach, serious involvement of all stakeholders and allocation of the needed resources, financial and otherwise is required [20].

SWM includes refuse from households, non-hazardous solid waste from industrial, commercial and institutional establishments (including hospitals and other health care facilities, market waste, yard waste and street sweepings). Semisolid wastes such as sludge and night soil are considered to be the responsibility of liquid waste management (LWM) systems. While hazardous industrial and medical wastes are, by definition, not components of municipal solid waste (MSW), they are normally quite difficult to separate from MSW, particularly when their sources are small and scattered. SWM systems should therefore include special measures for preventing hazardous materials from entering the waste stream and, to the extent that this cannot be ensured, alleviating the serious consequences that arise when they do. Finally, debris from construction and demolition constitute "difficult" categories of waste which also require separate management procedures.

## 3. National program and projects

In the 1990s the government of Egypt had clearly opted for a policy of waste recovery, focusing mainly on composting[23]. Compost is considered an attractive product because of its possible use as a soil conditioner for desert reclamation schemes. The national policy comprises the construction of two windrow composting plants in each Governorate of Egypt, preferably by using locally manufactured equipment.

Most recently, in 1999, the government of Egypt has developed and partly implemented a plan to fully privatize solid waste management including waste collection, composting and disposal in nine governorates. For the time being, only Alexandria is working on this privatization project. The tender document has been made, the tender has been publicized, and the bidders have submitted their bids, which are now under evaluation. After that, the other governorates will follow.

It is expected that the informal private collectors and recyclers will be important parts of any new system where no single company would be able to do the whole job by itself. At the same time, the informal private waste collectors are rather familiar with waste collection techniques than the other sectors, so as the informal waste recyclers, who may represent the instant market for the sorted recyclable materials[24,25].

A national management and information system for hazardous materials and wastes is currently under development within the auspices of the Egyptian Environmental Affairs Agency (EEAA) in collaboration with all stakeholders and involved government authorities. Parallel endeavors are also being undertaken by EEAA jointly with the Ministry of Health to cope with the alarming situation of medical wastes. Various management schemes and technology options are being assessed. As for industrial hazardous waste, two systems for Greater Cairo (including Cairo, Giza, and Qaliobia) and Alexandria are being planned for implementation. Parallel efforts are being made in new industrial cities, particularly from the standpoint of establishing proper secure landfills for final disposal.

It is important to note the big differences in Egypt between solid waste generation (arising) and the amounts reaching final disposal sites. In developed countries, the two figures are usually much the same since most waste arising must be disposed of formally (although there are moves towards the segregation of some components of waste at the source in a number of countries). In developing countries, including Egypt, much more of the waste arising is recovered, not least by scavengers, before it reaches the point of final disposal. Indeed, many materials that are deemed worthless in developed countries are justifiably recovered from waste and then reused in developing countries[26].

## 4. Waste characteristics

Waste characteristics vary according to the extent of urbanization, the income level of the area, and the degree of its industrialization and commercialization.

The density of solid waste arising varies according to point of measurement (at source, during transportation, at disposal) but averages about 300 kg/m$^3$ in Egypt (Table 3). This is significantly higher than solid waste densities found in developed countries, but is comparable to those found in other developing countries. Waste density is another important measure used to define the number and capacity of waste storage and collection facilities required. Based on waste density and the capacity of trucks, the amount of waste collected can be measured in tones (weight). The relatively high density measured in Egypt reduces the effectiveness of compaction vehicles for waste transportation (Arab Republic of Egypt, National Environmental Action Plan, Cairo, 1992).

The composition of municipal waste depends to a large extent on the affluence of the population contributing to the waste stream. It is essential to know the composition of waste, both at the source and at disposal, to assess the most suitable option for disposal and recovery. For example, the feasibility of composting is determined by a combination of the quantities of waste generated and the proportion of organic waste, amongst other factors. An example of a typical composition of solid waste in Egyptian cities is shown in Table 4 (EEAA. Action Plan for Sanitary Landfills in Egypt, 1998).

The zabbaliin have since expanded their activities and now take the waste they collect back to their garbage villages where it is sorted into recyclable components: paper, plastics, rags, glass, metal and food. The food waste is fed to pigs and the other items are sold to recycling centers.

**Table 3**
Solid waste densities around the world.

| Country | Density of solid waste (kg/m$^3$) |
|---|---|
| Developed countries | |
| United state | 100 |
| United kingdom | 150 |
| Developing countries | |
| Tunisia | 175 |
| Nigeria | 250 |
| Thailand | 250 |
| Indonesia | 250 |
| Egypt | 300 |
| Pakistan | 500 |
| India | 500 |

**Table 4**
Typical composition of solid waste in Egyptian cities.

| Waste composition | % |
|---|---|
| Organic waste | 60 |
| Paper | 10 |
| Plastic | 12 |
| Glass | 3 |
| Metals | 2 |
| Textiles | 2 |
| Others | 11 |

Source: EEAA. Action Plan for Sanitary Landfills in Egypt, 1998.

## 5. Conclusion

The direction for use the EM technology for solid waste treatment in Egypt may be decrease the accumulation of these wastes in house, street and another place and help for reuse these wastes again in right site.

## Conflict of interest statement

We declare that we have no conflict of interest.

## References


[1] Azab MS. Waste-waste treatment technology and environmental management using sawdust bio-mixture. *JTUSCI* 2008; **1**: 12-23.

[2] Chui CH, Hau DK, Lau FY, Cheng GY, Wong RS, Gambari R, et al. Apoptotic potential of the concentrated effective microorganism fermentation extract on human cancer cells. *Int J Molecular Med* 2006: **17**(2): 279-284.

[3] Zhao X, Wang Y, Ye W, Borthwick AGL, Ni J. Oil field wastewater treatment in biological aerated filter by immobilized microorganisms. *Proc Bioch* 2006; **41**(7): 1475-1483.

[4] Javaid A. Foliar application of effective microorganisms on pea as an alternative fertilizer. *Agronomy Sustainable Dev* 2006; **26**: 257-262.

[5] Sangakkara UR. *The technology of effective microorganisms -Case studies of application.* Research Activities Cirencester, UK: Royal Agricultural College, Cirencester; 2002.

[6] Khaliq A, Abbasi MK, Hussain T. Effects of integrated use of organic and inorganic nutrient sources with effective microorganisms (EM) on seed cotton yield in Pakistan. *Biores Tech* 2006; **97**: 967-972.

[7] Higa T, Chinen N. *EM treatments of odor, waste water, and environmental problems*. Okinawa, Japan: College of Agriculture, University of Ryukyus; 1998.

[8] Jochen M, Susanne S, Hans-Rudolf. *How effective are effective microorganisms? Results from an organic farming field experiment*. Modena, Italy: 16th IFOAM Organic World Congress; 2008.

[9] Zhao X, Wang Y, Ye ZF, Ni JR. Kinetics in the process of oil field wastewater treatment by effective microbe B350. *China Water Wastewater* 2006; **11**: 350-357.

[10] Ke B, Xu Z, Ling Y, Qiu W, Xu Y, Higa T, et al. Modulation of experimental osteoporosis in rats by the antioxidant beverage effective microorganisms-X (EM-X). *Biomed Pharmacother* 2009; **63**(2): 114-119.

[11] Freitag DG. The use of Effective Microorganisms (EM) in organic waste management. *Effective Microorganisms* 2003. [Online] Available from: www.emtrading.com.

[12] Prakhar PE, Arup KS. *Donnan membrane process: principles & application in coagulant recovery from water treatment plant residuals*. Bethlehem, Pa: Lehigh University; 1998.

[13] Elmitwalli TA, Al-Sarawey A, El-Sherbiny MF, Zeeman G, Lettinga G. Proceeding of 5th International Water Association conference in "Small Water and Wastewater Treatment Systems"Turkey. *J Environ Sci Health, Part* A 2002.

[14] El-Sherbiny M, Al -Sarawey A, Elmitwalli T. *Aerobic biodegradability of Egyptian domestic sewage*. In: Proceeding "Environment 2001" of Egyptian Ministry for Environmental Affairs, Cairo, Egypt; 2001.

[15] Ibrahim GEA. *Comparative study to evaluate different technologies for sewage treatment in rural areas in Egypt*. Ph. D. thesis. Alexandira, Egypt: High Institute of Public Health, Alexandria University; 1995.

[16] Daiss N, Lobo MG, Gonzalez M. Changes in postharvest quality of Swiss chard grown using 3 organic preharvest treatments. *J Food Sci* 2008; **73**(6): S314-320.

[17] Myint L, Ranamukhaarachchi SL. Development of biological control of *Ralstonia solanacearum* through antagonistic microbial populations. *Int J Agriculture Biol*. 2006; **8**(5): 657-660.

[18] Liu Y, Chung Y, Xiong Y. Purification and characterization of a dimethoate-degrading enzyme of *Aspergillus niger* ZHY256, isolated from sewage. *Appl Environ Microbiol* 2001; **67**: 3746-3749.

[19] Abdel-Megeed A, El-Nakieb FA. Bioremediation of dimethoate by effective microorganisms in Egyptian contaminant water. *J Applied Sci Res* 2008; **4**: 1-10.

[20] Daiss N, Lobo MG, Socorro AR, Bruckner U, Heller J, Gonzales M. The effect of three organic pre-harvest treatments on Swiss Chard (Beta vulgaris. L var. cycla L.) quality. *European Food Res Technol* 2008; **226**(3): 345-353.

[21] Zhou S, Wei C, Liao C, Wu H. Damage to DNA of effective microorganisms by heavy metals: Impact on wastewater treatment. *J Environmental Sciences* 2008; **20**(12): 1514-1518.

[22] Palmisano, Anna C, Barlaz, Morton A, editors. *Microbiology of solid waste*. New York: CRC Press, Inc.; 1996.

[23] Priyadi K, Hadi A, Siagian TH, Nisa C, Azizah A, Raihani N, et al. Effect of soil type, application of chicken manure and effective microorganisms on corn yield and microbial properties of acidic wetland soils in Indonesia. *Soil Science Plant Nutrition* 2005; **51**: 689-691.

[24] Shaxson TF. Re-thinking the conservation of carbon, water and soil: a different perspective agronomy for sustainable development. 2006; **26**: 9-19.

[25] Kautz T, Lopez-Fando C, Ellmer F. Abundance and biodiversity of soil microarthropods as influenced by different types of organic manure in a long-term field experiment in Central Spain. *Appl Soil Ecol* 2006; **33**: 278-285.

[26] Hussain T, Anjum AD, Tahir J. Technology of beneficial microorganisms. *Nat Farming Environ* 2002; **3**: 1-14.