ZIBELINE INTERNATIONAL PUBLISHING

ISSN: 1024-1752
CODEN : JERDFO

Journal of Mechanical Engineering Research and Developments (JMERD)
DOI : http://doi.org/10.26480/jmerd.03.2018.01.05

CrossMark

DESIGN OF SOLID WASTE SEPARATION EQUIPMENT IN BAGHDAD CITY

Nadhim M. Faleh[1], Itimad D J Azzawi[12]*

[1] Mechanical Engineering, University of Mustansiriyah, Baghdad, Iraq
[2]Mechanical Engineering, University of Diyala, Baqubaa, Iraq
***Corresponding Author Email:** itimad1981@gmail.com*

ARTICLE DETAILS

Article History:

Received 23 May 2018
Accepted 24 September 2018
Available online 27 September 2018

ABSTRACT

A massive number of weapons and solid waste are experienced since 1980 in Baghdad. The new government was forced to bury the solid waste in vast tracts, which is limited to waste pressing only without any separation process or recycling. As consequence, the environment suffers from pollution which can lead to various types of disease. According the local government of Baghdad city, the daily waste rate produced is about 11 thousand tons, which equivalents to more than 4 million tone every year. Without recycling this quantity of waste can therefore become a danger to the environment. Therefore, this study was seeked for two aims, initially, a statically information about the selected site was produced, then a machine for recycling process to eliminate reservation of large area used as a landfill was designed. Moreover, this machine was investigated analytically and experimentally system in the current study to separate three types of waste: PVC, glass and paper. This system is designed to be worked in automated minor to increase speed of operations and reduce costs. The results showed that this machine is a good first step for waste separation process.

KEYWORDS

Recycling, solid waste, automatic separation process, operation for reduce costs.

1. INTRODUCTION

The first necessary step is to produce some information about the site selected in the current study. The capital city of Iraq "Baghdad city" is the site selected city which shown in Figure 1. The figure clearly showed how the number of publication made it the largest city in Iraq (24% of Iraq) and second largest city in the Arab home after the Cairo. Therefore, the municipal authorities in the Baghdad cities are facing the biggest challenge for collecting, disposal and recycling of solid waste to decrease the generated waste amount in the country [1,2]. Global waste has increased about 28% from 5.6 Mt in 1997 to 7.65 Mt in 2007 and is assessed to further increase by 30% in 2020 [3,4]. Figure 2 gives the composition of wastes in Baghdad city. These types of waste are produced in various forms by human activities (industrial, domestic, commercial, and construction) and animals. Some of the waste fall out of the commercial use which cannot be reused. Most of these waste, if not treated, can lead to harm the environment and increase the pollution and directly proportional to the population growth. This fact enforced a major problem facing the world such that it is 10% of human life is lost due to the waste related disease [5,6]. Moreover, it is remarkable that unsuitable waste management will cause air, water and soil pollution.

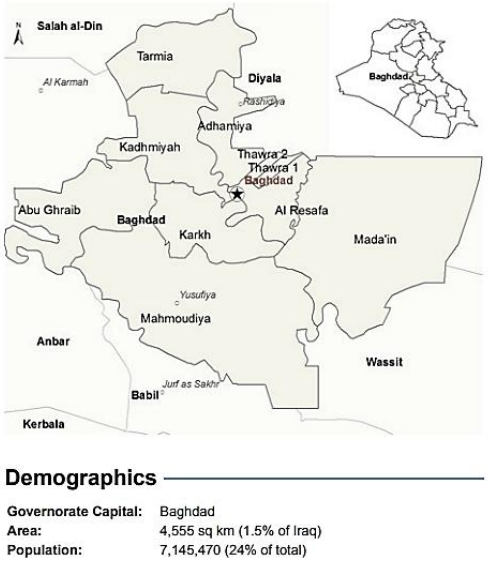

Figure 1: Site selected information and demographics

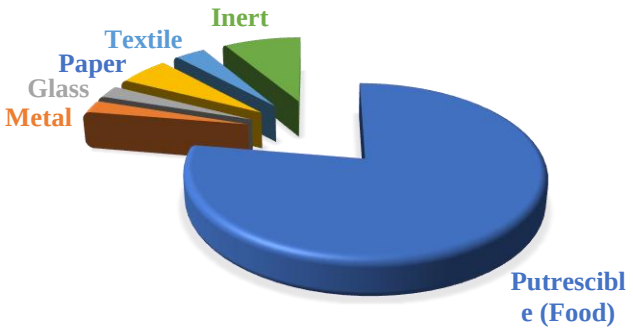

Figure 2: Components of municipal solid waste as weight percent in Baghdad city

In addition, the waste types mentioned in Figure 2, there are some other contaminations due to the wars (from 1980 to 2003) in Iraq and contaminated sites can be presented in Figure 3 [7]. Therefore, the overall aim of such measure is to guarantee maintainable development and treatment of waste in sound manner to reduce its impact on human beings and the environment [8].

Figure 3: Contaminated sites in Iraq with DU [7].

Therefore, the overall aim of such measure is to guarantee maintainable development and treatment of waste in sound manner to reduce its impact on human beings and the environment [8]. To reduce the amount of the solid waste, "Reuse, Recycle and Recover" are the basic solution while solid waste burial is the last solution can be used [9,10]. Currently, Iraqi government is concentrated on the burial of solid waste. This technique is required careful selection of site and landfill safe design to protect the population and environment. There are no ideals procedures for site selection criteria to be internationally followed [11-13]. However, from the factors used by various authors, it was noticed that the most appropriate criteria to be utilized are shown in Table 1. Based on the information available, the Iraqi government is used wrong procedure for the burial of solid waste in terms of distance and specifications shown in Table 1 [12, 14-25]. Moreover, the estimated landfill volume required to bury the waste based on the population growth by 2027 is about 138 Mm3 [26].

Waste treatment includes a lot of different processes. Besides from the organizational, structural and technical monitoring information of waste treatment should also be considered. Processing falls under the heading of physical treatments by using physical techniques to modify the composition and forms of the waste. Anytime making a recycling process means a conversion of the material to a new material named raw material which can be reused or transformed in useful goods. Recycling process conduce to reduce the amount of waste from landfill and the area of the landfill used too. So, to achieve the goal, the garbage materials need to be initially separated; because a good separation of the garbage from the beginning could support the next steps and give efficacy of the facilities which deals with the waste. Mechanical treatment is defined like the process of sorting and separation aggregates with the purpose to separate for reuse single materials from the waste stream of the city's solid waste such as size reduction, classification, separation and compaction. Typical aggregates in mechanical separation need different types of sorting and separation methods: (1) Some aggregates for size decrease, classification, separation of the waste. (2) Pre-alter the steam of the waste and collect able to recycle materials out of the waste stream. (3) Separate ferrous/ nonferrous metals, fractions of light, different plastics kinds, glass, passive materials fast and easy.

2. METHODOLOGY

Iraq is known as one of the most populated Arab countries with people greater than 32 million. Rapid development of economic, high growing of population, increasing separate profits have led to worse solid waste managing problem in the country. 31,000 tons of solid waste is produced in Iraq every day with more than 1.4 kg per day of per capita waste generation. Greater than 1.5 million tons of solid wastes are produced in Baghdad alone each year. A big strain is put on the infrastructure of Iraqi waste due to the rapid growing in waste generation production which been heavily damaged next years of conflict and mismanagement. This study is firstly concerned with analyzing of information on the annual rate of waste in Baghdad its components, in preparation for the design and construction scheme to solve the problem. Then, Gravity separation method was used based on the differences in specific gravity (SG) to attain a proper waste separation.

Table 1: Data sets required for the landfill site selection process [12, 14-25].

Constraint	Distances and specifications
Sites situated within the following distances are preferred for landfill sites 5 km to 10 km	Built-up area
>5 km	Airports
Depends on the landscape and the main wind path	Public parks and recreation areas
Low absorptivity (106 cm/s).	Soil
>100 m	Faults
>200 m	Flood plains
>5 km	Roads
Drainage should be away from the site and the slope is <5%	Topography and slope
> at least 3 kilometers away from protected areas or areas used for breading or living animals	Biodiversity
>3 km	Political borders
>125 m	Oil pipeline
Sites with area less than 20 hectares should be excluded	Site capacity
Sites with upwind dominant direction must be avoided	Wind direction
Not visible to the public	Visibility

3. SEPARATION PROCEDURE

After the problem was specified, a gravity separation method was used which is working based on differences in specific gravity (SG) among several minerals to attain a separation. This technique is a wet procedure although the separators of the dry gravity instances is existed. Gravity separation method works very well when there is a big alteration in the SG in the minerals that need to be separated. Moreover, the particle size is the same and not excessively fine with a circular shape.

In this study, the experiments are designed to have operating conditions that can produce the separation applications. This study is attempted to use a local analysis to identify the relatively composite percent in the waste in Baghdad. A combination of plastic waste 52%, aluminum cans 34% and rest of paper, dust and food crumbs were identified. The system described in Figure 4a, consists of Vibrated Beam; Part 1, which is built on the principle of size separation, at the end of which small-scale waste is disposed. The plastic waste is then separated from aluminum cans by rotor in the separation unit no.4.

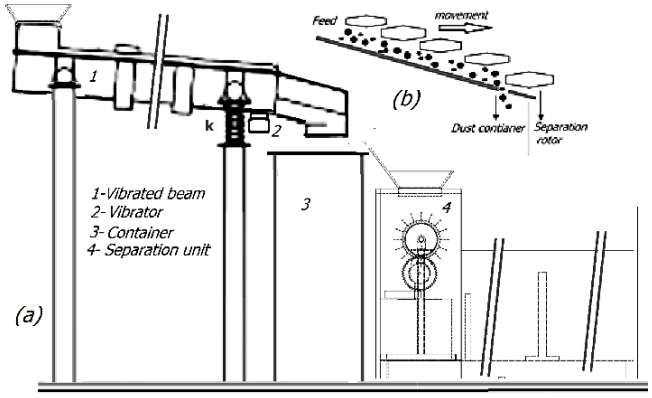

Figure 4: Separation system designed

Williams has stated that when a big particle get to be localized at the base of a vibrated container, the particle will rise always and reach a height in the belt that depends on vibration strength [29]. However, as quantities are not precisely defined, it is difficult to obtain more than a qualitative picture because it is unclear in which limit this experiment was done. Williams found that the large particle rises above critical amplitude and reaches an equilibrium height that depends on the vibration strength [30]. A sketch of the particle positions is shown in Figure 4b.

In the regime where vibration frequency is small, the system does not remain fluidized throughout the cycle even for large amplitudes. This is the regime in which the MC simulations were applied to make size separation [27]. But first let consider that the gravity and density of variation for a set of multi sized particles located in a vibrated beam. For a normal case, the volume and density are well-defined. However, the behavior of separation is based on two things: the normal frequency of the system, and then the frequency emitted by the vibrator. Therefore, the oscillator was being represented as shown in Figure 5, and the covering equations of the application were carefully studied.

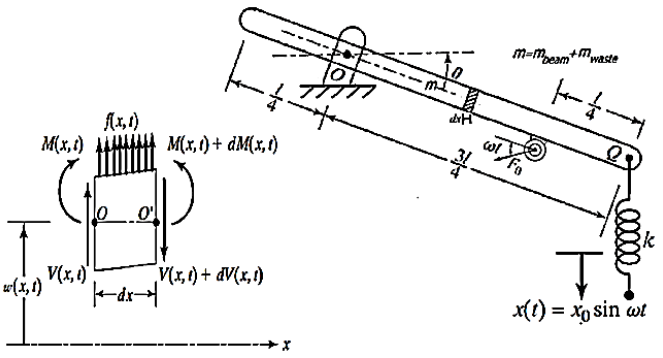

Figure 5: Modeling of vibrated beam

E is the elastic modulus, I is the second moment of area and *f (x,t)* is the applied external force. The beam with length *l*, and with conditions as shown in Figure 5, that is given by:

From the free body diagram (FBD) as shown in Figure 5, and according to newton's 2nd law:

$$-(V+dv)+V+f(x,t)dx=\rho A(x)dx\frac{\partial^2 w}{\partial t^2} \tag{1}$$

Where *W(x,t)* is the transverse displacement of the beam, ρ is the density of the beam, A is the cross sectional area,

$$\sum Mo=0$$
$$M+dM-(V+dv)dx+V+f(x,t)dx\frac{dx}{2}-M=0 \tag{2}$$

$$dV=\frac{\partial V}{\partial x}dx \quad and \quad dM=\frac{\partial M}{\partial x}dx$$

Disregarding terms involving second powers in dx (1) and (2) can be written as

$$-\frac{\partial V}{\partial x}(x,t)+f(x,t)=\rho A(x)dx\frac{\partial^2 w}{\partial t^2}(x,t) \tag{3}$$

$$\frac{\partial M}{\partial x}(x,t)-V(x,t)=0$$

Sub in eq. (3) become:

$$-\frac{\partial^2 M}{\partial x^2}+f(x,t)=\rho A(x)\frac{\partial^2 w}{\partial t^2} \tag{4}$$

From the theory of elementary of bending of beams (also known as the Euler-Bernoulli), the relationship between the deflection and bending moment can be expressed as:

$$M(x,t)=EI\frac{\partial^2 w}{\partial x^2}(x,t) \tag{5}$$

Where E is Young s modulus and I(x) is the moment of inertia of the beam cross section about the y-axis. Inserting Eq. (5) into Eq. (4) we obtain the equation of motion for the forced lateral vibration of a no uniform beam:

$$\frac{\partial^2}{\partial x^2}\left[EI(x)\frac{\partial^2 w}{\partial x^2}(x,t)\right]+\rho A(x)\frac{\partial^2 w}{\partial t^2}(x,t)=f(x,t) \tag{6}$$

For a uniform beam, and for free vibration Eq. (6) reduces to

$$c^2\frac{\partial^4 w}{\partial x^4}(x,t)+\frac{\partial^2 w}{\partial t^2}(x,t)=0 \qquad Where \quad c=\sqrt{\frac{EI}{\rho A}} \tag{7}$$

The free-vibration solution can be initiate using the method of variables separation as

$$W(x,t)=W(x)T(t) \tag{8}$$

Substituting Eq. (7) into Eq. (8) and rearranging leads to:

$$\frac{d^4W(x)}{dx^4}\frac{c^2}{W(x)}=-\frac{1}{T}\frac{d^2T(t)}{dt^2}=a=-\omega^2 \tag{9}$$

Equation (9) can be written as two equations:

$$\frac{d^4W(x)}{dx^4}-\beta^4W(x)=0$$

$$\frac{d^2T(t)}{dt^2}+\omega^2T(t)=0$$

Where

$$\beta^4=\frac{\omega^2}{c^2}=\frac{\rho A\omega^2}{EI}$$

$$\therefore T(t)=A\cos\omega t+B\sin\omega t \quad and W(x)=$$

$$C1\cos\beta x+C2\sin\beta x+C3\cosh\beta x+C4\sinh\beta x$$

Where A and B are constants that can be found from the initial conditions, while C1, C2, C3, C4, are different constants can be found from the boundary conditions. Based on Singiresu, the natural frequencies of the

beam are computed as [28]:

$$\omega = \beta^2 \sqrt{\frac{EI}{\rho A}} = (\beta l)^2 \sqrt{\frac{EI}{\rho A l^4}}$$

Now by applying the boundary conditions:

$$\frac{\partial W(x)}{\partial x} = -C1\beta \sin \beta x + C2\beta \cos \beta x + C3\beta \sinh \beta x + C4\beta \cosh \beta x$$

$$\frac{\partial^2 W(x)}{\partial x^2} = -C1\beta^2 \cos \beta x - C2\beta^2 \sin \beta x + C3\beta^2 \cosh \beta x + C4\beta^2 \sinh \beta x$$

$$\frac{\partial^3 W(x)}{\partial x^3} = C1\beta^3 \sin \beta x - C2\beta^3 \cos \beta x + C3\beta^3 \sinh \beta x + C4\beta^3 \cosh \beta x$$

At x=L/4=1/4

Deflection=W=0, bending moment EI (∂^2 W(x))/ (∂x^2)

At X=L

$$\frac{\partial}{\partial x}\left(\frac{\partial^2 w}{\partial x^2}\right) = kwEI \frac{\partial^2 W(x)}{\partial x^2} = 0 \qquad and$$

$$W(l/4) = C1 \cos l\beta/4 + C2 \sin l\beta/4 + C3 \cosh l\beta/4 + C4 \sinh l\beta/4 = 0$$

E B.C 1

$$-C1\beta_5 \cos \beta l/4 - C5\beta_5 \sin \beta l/4 + C3\beta_5 \cos \beta l/4 + C4\beta_5 \sin \beta l/4 = 0$$

$$\frac{\partial^2 W(l/4)}{\partial x^2} = 0$$

E B.C.2

$$\frac{\partial^3 w(4)}{\partial x^3} = kw(4)$$

$$C1\beta^3 \sin 4\beta - C2\beta^3 \cos 4\beta + C3\beta^3 \sinh 4\beta +$$
$$C4\beta^3 \cosh 4\beta = C1k \cos 4\beta + C2k \sin 4\beta + C3k \cosh 4\beta + C4k \sinh 4\beta$$

E B.C.3

$$\frac{\partial^2 W(l)}{\partial x^2} = 0$$

E B.C.4

From $-C1\beta^2 \cos l\beta - C2\beta^2 \sin l\beta + C3\beta^2 \cosh l\beta + C4\beta^2 \sinh l\beta = 0$

above four equations, C1, C2, C3, and C4 can be found and the steady state response of forced vibration can be expressed as:

$$EI \sum_{n=1}^{\infty} \frac{d^4 W(x)}{dx^4} q_n(t) + \rho A \sum_{n=1}^{\infty} W_n(x) \frac{d^2 q_n(t)}{dt^2} = f(x,t) \qquad (10)$$

Where $q_n(t)$ is the generalized coordinate in the nth mode.

$$\sum_{n=1}^{\infty} \omega_n W_n(x) q_n(t) + \sum_{n=1}^{\infty} W_n(x) \frac{d^2 q_n(t)}{dt^2} = \frac{f(x,t)}{\rho A} \qquad (11)$$

Now multiply both sides of above Eq. by $W_m(x)$ ((where $W_m(x)$ orthogonal with $W_n(x)$. And integral from 0 to l

$$\sum_{n=1}^{\infty} \omega_n q_n(t) \int_0^l W_n(x) W_m(x)\, dx + \sum_{n=1}^{\infty} \frac{d^2 q_n(t)}{dt^2} \int_0^l W_n(x) W_m(x) dx = \frac{1}{\rho A} \int_0^l W_n(x) f(x,t) dx$$

But from orthogonal property ($\int_0^l W_n(x) W_m(x)\, dx = 0$) for any n≠m

$$W_n^2 q_n(t) + \frac{d^2 q_n(t)}{dt^2} = \frac{1}{\rho A b} Q_n(t)$$

Where:

$$b = \int_0^l W_n^2(x) dx$$

$$Q_n(t) = \int_0^l W_n(x) f(x,t) dx \qquad (12)$$

Where $Q_n(t)$ is called the generalized force corresponding to $q_n(t)$:

$$q_n(t) = A_n \cos \omega_n t + B_n \sin \omega_n t + \frac{1}{\rho A b \omega_n} \int_0^l Q_n(\tau) \sin \omega_n (t-\tau) d\tau$$

With this fabrication from Figure 4, the size separation in the vibrated granular matter, dust, and food crumbs leave at the end of the vibrated beam, while the water bottles and juice containers all get for the rotor of separation unit like is shown in Figure 6. Equation (12) determines the size of vibrated gate produced based on the factors and specifications specified in Equation (1) and unbalanced mass in vibrator. It is often need a value of W(x,t) at the right end of beam, that not exceeding 6 mm, to ensure dust and granules are disposed without bottles and containers. Separation unit assembly that is uses a track and a rotor to sort waste as shown in Figure 6. This method had been chosen since it is the most efficient method used to convert projectile kinetic energy into size separation.

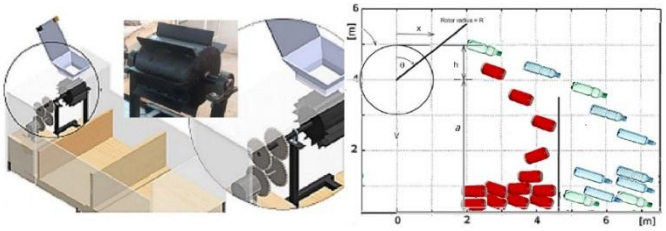

Figure 6: Separation unit assembly

Based on Figure 6, by simple trigonometry, it is:

$$than\ (theta) = \frac{x(t)}{h} \qquad (13)$$

With x(t) representing the linear position of the sphere along the track. Substituting theta= wt and using v(t) as time derivative of x(t) then by substituting into equation (16) the velocity of this linear path results in:

4. $$Vo = \frac{R2\, w}{h} \qquad (14)$$

4. CONCLUSIONS

This article is presented statistical information about different types of waste in Baghdad city. Based on the information available in the previous studies, the Iraqi government is used wrong procedure for the burial of solid waste in terms of distance and specifications shown in Table 1. Moreover, the estimated landfill volume required to bury the waste based on the population growth by 2027 is about 138 Mm^3. Therefore, this study was tried to use the concept of segregation the waste by mechanical vibration and separation by rotation of waste treatment field. This concept is conducted built on a physical and a mathematical description at the mechanical system of separation occurring under vibration and rotational characteristic. The mechanical method in the separation of waste, in this study, was based on the waste components in the study area of Baghdad; this method of treatment has been chosen to reduce the value of manual effort in the waste separation process and hence reduce the area used for landfill.

REFERENCES

[1] Femi, F., Oluwole, O. 2013. Management of Municipal Solid Waste.

[2] Al-Ansari, N.A. 2013. Locating Landfills in Arid Environment. Journal of Earth Sciences and Geotechnical Engineering, 3, 11-24.

[3] Low Sheau, T., Tee, S., Choong, W. 2016. Preferred Attributes of Waste Separation Behaviour: An Empirical Study. Procedia Engineering, 145, 738 – 745.

[4] Tan, S.T., Ho, W.S., Hashim, H., Lee, C.T., Taib, M.R., Ho, C.S. 2015. Energy, economic, and environmental (3E) analysis of waste-toenergy (WTE) strategies for municipal solid waste (MSW) management in Malaysia. Energy Conversion and Management, 102, 111-120.

[5] MSNC. 2007. Malaysia Second National Communication to the UNFCCC. ISBN 978-983- 44294-9-2.

[6] Pearce, D., Walker, C.H. Sustainable development. In: Baily, R., Ed.," Water and Environmental Management in Developing Countries, Amazon Company, UK.

[7] Chulov, M. 2010. Iraq littered with high levels of nuclear and dioxin contamination," study finds.

[8] Aldiab, S. 2000. The gap between planning and execution of environmental policies in Jordan: A case study of Jordan valley. Thesis, Al al-Bayt University, Jordan.

[9] Al-Muqdadi, K. 2006. Beware of scrap iron from the remnants of war. Environment and Development, 8, 16- 21.

[10] Enger, E.D., Smith, B.F. 1995. Environmental science, a study of interrelationships. 6th Edition, WCB, McGraw-Hill, Washington DC.

[11] Malczewski, J. 1999. GIS and multicriteria decision analysis. John Wiley & Sons, Inc., New York.

[12] Dikshit, A.K., Padmavathi, T., Das, R.K. 2000. Locating potential landfill sites using geographic information system. Journal of Environmental Systems, 28, 43-54.

[13] Lin, H.Y., Kao, J.J. 1999. Enhanced spatial model for landfill siting analysis. Journal of Environmental Engineering, 125, 845-852.

[14] Al-Ansari, N.A., Al-Hanbali, A., Knutsson, S. 2012. Locating solid waste landfills in Mafraq City, Jordan. Journal of Advanced Science and Engineering Research, 2, 40-51.

[15] Sloan, W.M. 1993. Site selection for new hazardous waste management facilities. WHO European Publica- tions European Series, 46, World Health Organization, Copenhagen.

[16] Basagaoglu, H., Celenk, E., Marino, M.A., Usula, N. 1997. Selection of waste disposal sites using GIS. Journal of the American Water Resources Association, 33, 455- 464.

[17] Bonham-Carter, G.F. 1994. Geographic information systems for geoscientists: modelling with GIS. Pergamon, Oxford.

[18] Hussey, V., Dodd, V.A., Dennison, G.J. 1996. Locating a landfill site for Dublin using geographic information systems. Proceeding of the Institution of Civil Engineers-Municipal Engineer, 115, 125-133.

[19] Kao, J.J., Lin, H.Y., Chen, W.Y. 1997. Network expert geographic information system for landfill siting. Journal of Waste Management and Research, 15, 239-253.

[20] Baban, M.J., Flannagan, J. 1998. Developing and implementing GIS-assisted constraints criteria for planning landfill sites in the UK. Journal of Planning and Research, 13, 139-151.

[21] MMBW. 1985. Melbourne and Metropolitan Board of Works "Off-site industrial waste storage treatment and disposal facilities": Proposed siting criteria. Melbourne and Metropolitan Board of Works, Australia.

[22] MWLAPC. 1993. Ministry of Water, Land and Air Protection-Canada "landfill criteria for municipal solid waste.

[23] Cheremisinoff, N.P. 2003. Handbook of solid waste management and waste minimization technology. Elsevier Science, New York, 477.

[24] Batstone, R., Smith, J.E.J., Wilson, D. 1989. The safe disposal of hazardous waste: The special needs and problems of developing countries. The World Bank Technical Papers, Washington DC, 1,2,3.

[25] Al-Meshan, O. 2005. Location criteria for domestic and hazardous waste disposal to landfill in the Jordanian Badia using GIS. PhD Thesis, Coventry University, Coventry.

[26] IMPDC. 2006. Iraqi minister of planning and development cooperation.

[27] Rosato, A., Stranburg, K., Prinz, F. 1987. Size segregation of particulate matter by shaking. Physical Review Letters, 58, 1038–1041.

[28] Singiresu, S. 2011. Mechanical Vibrations. Prentice Hall, ISBN 978-0-13-212819-3.

[29] Williams, J. 1963. The segregation of powders and granular materials. Energy & Fuels, 14, 29–34.

[30] Arshad, K. 2004. Size separation in vibrated granular matter. Reports on Progress in Physics, Institute of Physics Publishing, Rep. Prog. Phys. 67.