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Impacts of Solid Waste Leachate on Soil and its Simulation to Ground Water at Nablus Area

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Submitted in Partial Fulfillment of the Requirements for the Degree of Master in Water and Environmental Engineer, Faculty of Graduate Studies, at An-Najah National University, Nablus, Palestine.
2006

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Dedication

To soul of my father, to my mother,

to my sisters, and to Rami with love

Acknowledgments

All praise to Allah for this accomplishment.

Thanks to Professor Marwan Haddad for his guidance, encouragements and supervision during this study and dissertation preparation.

I would like to record my special thanks to my mother and to my family for their efforts in all steps of my life and combine harvesting

Thanks to Dr. Mohammad Al Masri and to all employees at the Water and Environmental Studies Center, thanks to Dr. Nidal Zatar and to all people who helped in this work.

At the end thanks to Salam and to all my friends.

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Abbreviations

ARIJ	Applied Research Institute-Jerusalem
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
EC	Electrical Conductivity
EPA	Environmental Protection Agency
FCSHWM	Florida Center for Solid and Hazardous Waste Management
LFG	Land Fill Gas
IWM	Integrated Waste Management
MSW	Municipal Solid Waste
MEnA	Ministry of Environmental Affairs
PCBS	Palestinian Central Bureau of Statistics
PEQA	Palestinian Environmental Quality Authority
PHG	Palestinian Hydrology Group
SAR	Sodium Adsorption Ratio
TDS	Total Dissolve Solid
TSS	Total Suspend Solid

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Abstract

Palestine is not like other countries; it has its special situation because of the Israeli occupation. The closure and segregation of the main roads of the Palestinian, leading to complicate the solid waste management problem and resulted in the usage of alternative uncontrolled dumping sites which may be polluted the soil and the ground water. The vulnerability map of West Bank notice that many Palestinian cities especially Nablus city have high vulnerability.

Neither short nor long term effect of MSW on soil and ground water in Palestine were not adequately evaluated and there is need to explore these effects and impacts.

So the aims for this study are: evaluate the temporal and spatial variations of MSW leachate in landfills, evaluate the impacts of MSW leachate on soil, and may be simulate the impacts of MSW leachate on ground water.

These aims achieved by establishing a model similar the real dump site, which consists of:

- Leachate extraction columns
- Leachate application to soil columns

Laboratory analyses:

- Leachate: the samples were analyzed for MSW leachate parameter which are: pH, EC, TSS, TDS, BOD_5, Ca, Mg, Na, K, CO_3, HCO_3, alkalinity, hardness, Sulfate, Phosphate, Nitrate, Cl, and Iron.
- Soil: the soil properties which we tested were classified under two different categories; physical and chemical properties.
  - Physical analyses are: pH, EC, sieve analysis, hydrometer test.
  - Chemical analyses are: Nutrition that consists of K, Nitrite, and Phosphorus. Salt source that consists of Na, Ca, Mg, Cl.

The results of this study demonstrated that

- TSS and TDS of MSW leachate were increased with MSW depth and decreasing with increasing water addition.
- SAR values of the soil impacted by MSW leachate and in all columns tested increased slightly with depth but remained within the excellent range of soils suitable for agricultural development.
- Removal of pollutants from MSW leachate by passage through a soil.
- Statistical analysis of quality data collected showed that responsive functions of elements under consideration using multiple liner regression were possible and adequately acceptable and can be used to predict those elements as a function of MSW elevation and extent of precipitation.

Chapter One

Introduction

1.1 Introduction

Palestine is not like other countries; it has its special situation because of the Israeli occupation, therefore, if we want to develop our country, we are faced with the objection of their government. We hope that we will have the rights to protect our country "Palestine" in all aspects especially what God grant all human beings such as "ground, water, and air".

Agriculture depends on good soil, water and light. So we need good soil and clean water for our life and our agriculture because it is our future.

Not only did the Israelis steal our land, but they also control its natural resources specially water, its sources in Palestine are ground water and rain water that recharge the ground water. So we must protect the ground water from pollution because the water treatment coasts a lot of money, in general the protection from pollution more efficient than treatment from it.

The ground water may be polluted if the recharge area of aquifer is polluted. The closure and segregation of the main roads of the Palestinian by Israeli, leading to complicate the solid waste management problem and resulted in the usage of alternative uncontrolled dumping sites which may be polluted the ground water. So the results of current situation are:

- Ground water is scarce for Palestine at present and in the future.
- MSW management may pollute soil and ground water.

The logical definition of groundwater pollution hazard is the interaction between the aquifer pollution vulnerability and the contaminant load that is applied on the subsurface of the environment as a result of human activity at land surface. The vulnerability map of West Bank notice that many Palestinian cities especially Nablus city have high vulnerability to pollution, and also the usage of alternative uncontrolled dumping sites will be increase pollution problem, and may decrease the time to pollute the ground water.

Scientific researches in Palestine on this topic with all its elements, variables and details have not been done yet. So the aims for this study are: evaluate the temporal and spatial variations of MSW leachate in landfills, evaluate the impacts of MSW leachate on soil, and may be simulate the impacts of MSW these aims achieved by establishing a model similar the real dump site, which consists of:

- Leachate extraction columns: consist of four columns different in elevation, MSW was put in each one, the variation in leachate quality can be attributed to composition, depth of waste, and waste age. Water was supplied on the top of each MSW columns, and distributed it on winter season, then analyses of the leachate.

- Leachate application to soil columns, there were 6 soil columns, each one contains soil from the same Nablus disposal dump site. The elevation of soil in each column = 2m. The leachate that was produced from each column of MSW was poured in each soil column. Then analyses of the soil and the leachate that came out of soil column. The other two columns of soil were used for other purposes, in the first rainfall was put in a 2m dump site soil column, in the second one leachate that came out of the 2m soil column was put in after passing through 1.5m MSW elevation. Then analyses of the soil and the leachate that came out of the soil column.

Managing Solid Wastes in the West Bank and Gaza Strip

The offered service of collecting solid wastes covers 67 percent of the West Bank population, the solid wastes in the West Bank and Gaza Strip are transferred outside the borders of municipalities to randomly chosen areas that contradict with the conditions of environment protection (PNIC, 1999). These solid wastes are not totally burned up; these wastes become a place for insects, rodents, and unpleasant smells, therefore, these wastes cause harmful effects to the public health (PNIC, 1999).

In the West Bank, approximately 381 thousand tons of MSW collected and dumped every year in 189 open and uncontrolled dumping sites, whereas the remaining waste, approximately 214 thousand tons, are dumped and burned every year on roadsides and vacant lands (PNIC, 1999), open burning of collected waste is practiced in all open dumping sites except Abu-Deis site in the Jerusalem district, where the waste is totally landfill, there are 100 sites in the West Bank for collecting plant wastes, the largest site, refuse dump, is located nearby Abu Deis Village on an area that measures 3000 donums, this area is under the Israeli control and it is allocated for serving the adjacent Israeli settlements (PNIC, 1999).

The regulations in the big cities at West Bank and Gaza Strip regarding the solid wastes dumps include the following:

1. Collecting garbage placed outside homes, by sanitation workers of the municipalities and UNRWA, and transferring it to small garbage bins or even the citizens can do such work by putting the garbage in plastic bags (PNIC, 1999).

2. The small garbage bins are taken away outside the areas to refuse dumps by the municipality trucks. However, 70 percent of the Palestinian residential areas lack the necessary regulations for collecting wastes (PNIC, 1999).

The solid wastes in Gaza Strip cannot be compared with the ones in the West Bank. However, the service of collecting solid wastes offered in Gaza Strip covers a larger percentage of population than the one in the West Bank due to the densely populated areas, the solid wastes in Gaza Strip are disposed of in scattered and small refuse dumps, there are two dumps for solid wastes; the first is in Gaza City and the second is in Deir Al-Balah, also, there is a refuse dump eastern Rafah city and a project proposal for another one eastern Gaza city, and the problems of solid wastes still exist in the north and south of Gaza Strip (PNIC, 1999).

In Gaza Strip, approximately 300– 350 thousand tons of solid wastes are generated every year, around 247 thousand tons are disposed of in sanitary landfills which are Gaza, Deir-el-balah, and Rafah landfills, the remaining waste is dumped and burned in uncontrolled dumping sites (ARIJ, 2005).

Table (1): The number of disposal sites along the coastline of Gaza Strip

Source of Pollution	No. of Sites
Sewage	31
Chemical Wastes	360
Household Refuse	362
Stones and Construction Wastes	521

(PNIC, 1999)

The management of solid waste in the Palestinian Territories has extremely deteriorated since the outbreak of the Second Palestinian Uprising

(Intifada) in 2000. This is due to the closure and segregation of the Palestinian localities as well as the closure of the main roads leading to the existing dumping sites by Israeli roadblocks and checkpoints (ARIJ, 2005). This has complicated the solid waste management problem and resulted in the usage of alternative dumping sites which increased the number of uncontrolled dumping sites. In the West Bank, the number of these uncontrolled sites increased from 89 before the outbreak of the Intifada to 189 until 2005 (ARIJ, 2005).

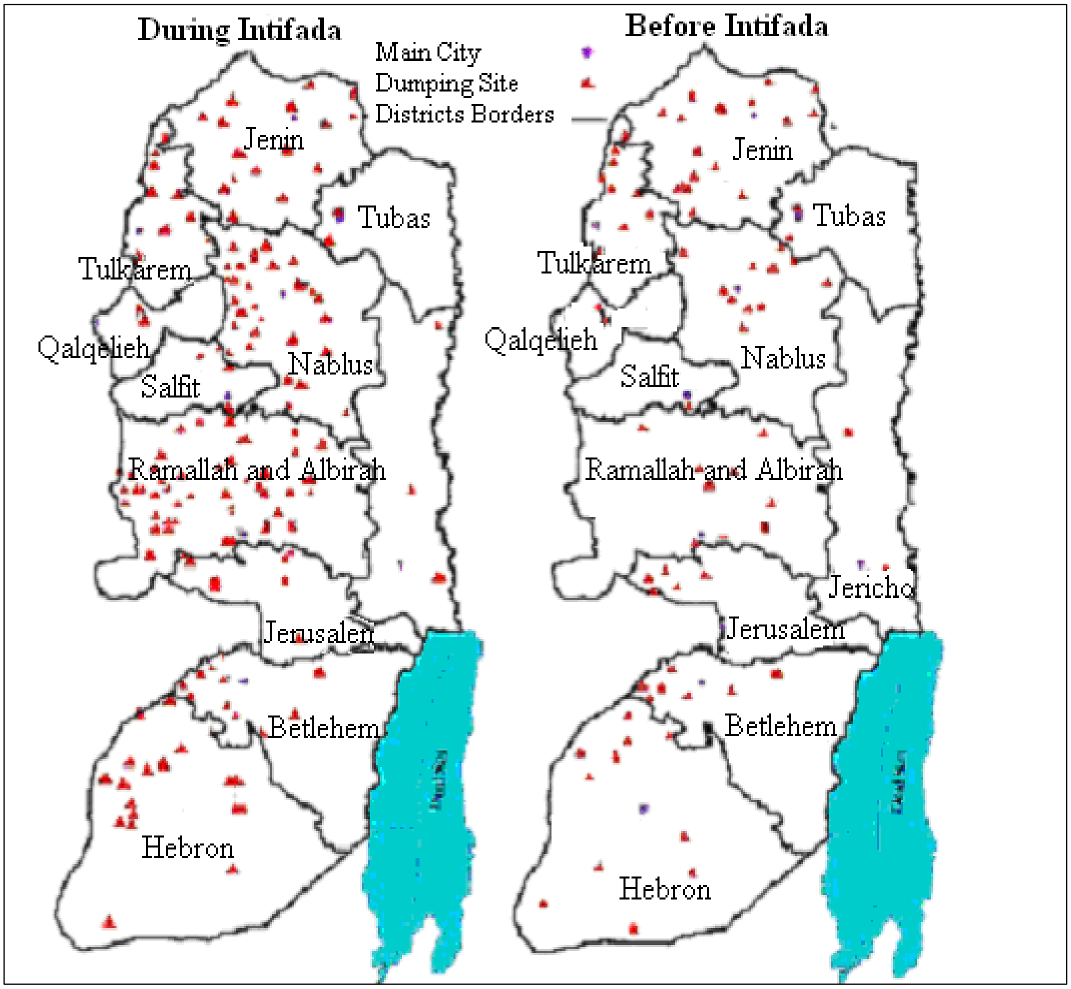

Figure (1): Dump site before and after Intifada 2000.

(ARIJ, 2005)

Some of the major problems that result from current solid wastes management in the Palestinian Territories are:

1. The decrease of the surface area of lands owing to their use as dumps for solid waste disposal

2. The inconvenience caused to people due to the unpleasant smells and the spread of insects that gather on these solid wastes as well as the emitted smoke from the burning of such wastes

3. The contamination of surface water and groundwater due to the decomposition of the solid wastes

4. Disfiguring landscapes (PNIC, 1999)

The Problem of Solid Wastes in the West Bank and Gaza Strip

The estimated weights of solid wastes in the West Bank and Gaza Strip in 1994 are 1000 tons a day, Thus the solid wastes in a year will equal 365 thousands tons. It is expected that the weight of solid wastes in the year 2010 will reach 3900 tons a day and in a year the weight will be 1423.5 thousand tons. The following table (#1) shows the expected amount of solid wastes in the West Bank and Gaza Strip for the year 2010 in comparison with 1994 (PNIC, 1999).

Table (2): Expected amount of solid wastes in Palestine**.**

Area	**Weight of Solid Wastes Ton/Day**		**Weight of Solid Waste1000 Ton/Year**		**Amount of Solid Wastes 1000 $\cancel{M}^3$**	
	1994	2010	1994	2010	1994	2010
Gaza Strip	400	1500	146	547.5	438	1643.5
West Bank	600	2400	219	876	657	2628
Total	1000	3900	365	1423.5	--	4271.5

(PNIC, 1999)

So the increase of the quantity of solid waste increases the random dump site, where this dump site may pollute the ground water, as Schwarz said.

“The landfill would worsen environmental damage (Schwarz, 1997)”. Damage is caused by pollution especially groundwater pollution, the definition of groundwater pollution hazard is the interaction between the aquifer pollution vulnerability and the contaminant load that is, will be or might be, applied on the subsurface environment as a result of human activity at land surface (Mimi et al, 2004). If we look at the vulnerability map of West Bank, we notice that many Palestinian citie especially Nablus city have high vulnerability to pollution the ground water see **Figure 2**. So many random dump sites may pollute groundwater.

Figure (2): Hydrogeological vulnerability of groundwater

(PEQA, 2002)

According to researchable and scientific factors, the reasons for poor solid waste management and its effects on soil and ground water hasn't been studied yet including factors and its parameters. So the aims for this study are: evaluate the temporal and spatial variations of MSW leachate in landfills, evaluate the impacts of MSW leachate on soil, and simulate the impacts of MSW leachate on ground water.

1.2 Water and its Contamination

Water is a vital commodity, but is very unevenly distributed in the earth. After studying the water budget, it becomes apparent that 97.3% of the worlds water is in salty oceans, and 2.1% is located in ice cap, a bar 0.06% is found in lakes, river, and grounds (Purdom, 1980).

Water is a scare resource in West Bank. Rainwater and groundwater are the only water source. One of the primary concerns of the Palestine people is having safe drinking water as well as water to assure their economic and agricultural development. The population growth, the expected industrial and economic developments make the protection of the available ground water resources from the different pollutant imperative (Marei, 1996).

The general way in which the chemical composition of ground water may be changed "Polluted":

Run off from agricultural and urban watershed, accidental spills and leaks, nature of groundwater contamination, waste-disposal practices are considered from the general important source of ground water contamination (Charbeneau, 2000).

Ground water pollution happens if the dump site is placed in recharges areas because “Groundwater flows from recharge area through groundwater reservoir to discharge area” (Ponce, 1989).

1.3 Disposal of Municipal Solid Waste Using Sanitary Landfill

In sanitary landfill, MSW is carried and dumped into the low lying area under an engineered operation design and operated according to the acceptable standards, as not to cause any nuisance or hazards to public health or safety (Garg, 1998).

In the sanitary landfill design and construction must include elements that permit control of leachate and gas. This major component of sanitary landfill includes liner, leachate collection and management system, gas management facilities, storm water management and final cap (Vesilind et al, 2002).

1.4 Solid Wastes and its Management in Palestine.

Solid wastes types in Palestine are:

1. Household wastes: the wastes of houses, hotels and restaurants.

2. Wastes of agricultural activities including both plant and organic wastes.

3. Wastes of industries.

4. Wastes of construction activities and various installations.

(PNIC, 1999).

Other types of wastes:

1. Hazardous Wastes, such as the chemical compounds, water and mineral solutions, mercury compounds which result from the chemical industries, electronic industries, paper industry (PNIC, 1999).

2. Medical Wastes: these are the garbage of medical laboratories, hospitals, private clinics, and veterinary health centers. The refuse containers used syringes, tubes, and containers (PNIC, 1999).

3. Biological Pesticides: these are used to protect humans, animals and plants from the harmful effects brought about by some insects, rodents, noxious herbs, fungi, and bacteria. The biological pesticides are very important as they largely contribute to the increase of agricultural production; Gaza Strip alone uses 100 tons of these pesticides (PNIC, 1999).

The risks of using such pesticides are associated with:

1. The disturbance of ecological balance, "dependence of organism on other"

2. The harm caused to the public health, especially to the users of pesticides

3. The contamination of surface water and groundwater (PNIC, 1999).

Table (3): Distribution of dumping in Palestinian

Region	Dump sites #	Solid waste type				
		Dangerous waste	Medical waste	Industrial waste	Agricul -tural waste	Muni -cipal waste
West Bank	**133**	**4**	**4**	**21**	**18**	**131**
Jenin	23	-	-	2	5	23
Tubas	1	-	-	-	-	1
Tulkarem	15	-	1	-	4	15
Nablus	16	-	1	2	2	**15**
Qalqilya	3	2	-	1	1	3
Salfit	9	2	-	2	1	9
Ramallah	32	-	1	3	-	32
Jericho	4	-	1	2	-	3
Jerusalem	9	-	-	1	-	9
Bethlehm	4	-	-	4	1	4
Hebron	17	-	-	4	4	17
Gaza Strip	**4**	**-**	**2**	**3**	**-**	**4**

(PCBS, 2002)

This table (#3) shows that the number of dumpsite is a huge number comber of the environment protection and the largest dump site type is municipal waste, which reach 131 dump site in the West Bank, and at Nablus city it have 15 municipal dump site, 2 agricultural dump site, 2 industrial dump site and it have only 1 medical dump site.

So because of the important of the effect of solid waste dump site, the Palestinian National Authority put the solid waste disposal site belong to major development project that shall be conducted by An Environmental

Impact Assessment (EIA), to protect Palestinian environment elements, especially groundwater (MEnA, 2000).

Despite the above explained about the dangerous of random dump site, the Palestinian Hydrology Group (PHG); made a study about the solid waste and dump sites in Palestine. They reported that Palestinian community, as any other community in the developing countries, suffers from lack of solid waste management systems. In most of Palestinian communities, municipalities or village councils collect and transport solid waste, and they manage the dumpsites where solid waste is disposed. As the collection and transport system are not efficient most of the time, people tend to dump their solid waste randomly in the streets or near the valleys.

The assessment of PHG group study on dumping sites of the West Bank where the current situation shows that there are serious environmental and health impacts in the villages studied because of the improper management of solid waste (PHG, 1999).

The problems of the existing solid waste management system, as defined by the PHG field investigation, can be summarized as follow:

1- Collection service is not organized

2- Transportation service is not efficient

3- Dumping takes place in open dumps

4- Environmental conditions at the dump site are extremely poor

5- Groundwater levels are high and wells are close to the dump sites

6- Air pollution from the open burning or self-ignition of the waste

7- Health conditions of the communities are poor

8- The community does not take the adverse impacts of the solid waste management seriously (PHG, 1999).

The PHG recommendations were:

1- Closure of the existing dumpsite “that randomly selected”

2- Selection of a new dumpsite where in this site the appropriate water quality criteria for each site will be specified by the detailed study

3- Development of a sustainable system for solid waste management (PHG, 1999).

1.5 Summary

The current situation are: ground water is scarce for Palestine at present and in the future, MSW management in Palestine is not well controlled and may result to pollute the soil and ground water as reason of huge number of random dumpsite on a high vulnerability land to pollution.

So neither short nor long term effect of MSW on soil and ground water in Palestine were no adequately evaluated and there is need to explore these effects and impacts.

1.6 Objectives

The study objectives are:

1- Evaluate the temporal and spatial variations of MSW leachate in landfills, it was achieved.

2- Evaluate and simulate the impacts of MSW leachate on dump site soil, it was achieved.

3- Evaluate impacts of MSW leachate on ground water, it was not achieved, so I recommended other researcher to achieve it.

Chapter Two

Background

2.1 Introduction

Landfill has been widely used for municipal solid waste (MSW) disposal all over the world. Especially in developing countries, it is considered to be a reliable and cost effective method if adequate land is available. However, improper management and operation of landfill could create severe environmental impacts such as groundwater pollution and nuisance odor.

Basic principle of conventional landfill design is to contain or store the wastes so that the exposure to human and environment could be minimized.

2.1.1 Solid waste leachate

Solid waste is useless, unwanted or discarded material normally in the solid state that arises from human activity (Vesilind, 2002).

As water percolates through the landfill, contaminants are leached from the solid waste, within a landfill a complex sequence of physical, chemical, and biological mediated events occurs through solid waste which arise leachate. As a result of consequence of these processes, refuse is degraded (Vesilind, 2002).

2.1.2 Types of solid waste

Solid waste can be divided by source into five categories which are municipal solid waste, industrial solid waste, sewage sludge, agricultural wastes, and mining waste (Bishop, 2000).

Municipal solid wastes (MSW): Means solid waste from single family and multifamily residences, hotels which consist of residential wastes (garbage, yard wastes, ashes from heating unit, and bulky wastes), commercial and institutional wastes (construction and demolition wastes), street refuse, dead animals, abandoned vehicles, and so on (Bishop, 2000).

Industrial solid waste: Means solid waste generally arise from two sources: process wastes remaining after manufacturing a product; and commercial institutional wastes from office activities, cafeterias, laboratories, and the like (Bishop, 2000).

Sewage sludge: The sludge left over after treating water or wastewater that must be handled properly to ensure public safety and minimize environmental damage (Bishop, 2000).

Agricultural wastes: Both crop residues that cannot be returned to the soil, and manure from animal feeding facilities (Bishop, 2000).

Mining waste: The mining industry produces such large amounts of solid waste that special emphasis should be given to this material. Unplanned spoil heaps impair the landscape, threaten land slides and pollute ground water (Al-Nori, 1999).

2.1.3 Integrated waste management

The basic of management option for integrated waste management (IWM) are: source reduction, recycling, composting, reuse, combustion waste to energy facilities, and landfill (Tchobanoglous, 2002).

Reasons for interest in waste recovery and recycling

1- Enormous increase in the quantity of solid waste.

2- Resource depletion

3- Limited capacity of land, air, and water to absorb the increasing quantities of waste (Vesilind, 2002).

2.1.4 Refuse disposal

The refuse can be disposed by various methods: some of these methods are sanitary land filling, burning or incineration, barging it out into the sea, composting by bacterial agency (Garg, 1998).

Actual actions in the disposal of the solid waste in the landfills are:

1- Dump or tip "Open placement of solid waste", where this dump site is considered collection places only, where the solid waste is collected on the surface of the earth and kept on it without any process or transportation to final disposal place may be landfill, or incineration (Veslined, 2002).

2- Sanitary landfill, which is one of the safety way of the final disposal of the solid waste, which protect human people and nature resources especially ground water (Veslined, 2002).

2.1.5 Factor affecting leachate quality

Leachate quality is highly variable. The variation in leachate quality can be attributed to many interacting factors such as the refuse density, time, (McBean. et al, 1995), composition and depth of waste, the availability of moisture and oxygen, landfill design in its operation (process waste), and waste age (FCSHWM, 1998).

1-Depth of Waste

Solid waste depth influences leachate composition. Increasing in refuse depth allow the percolate to approach its solubility limit, there by reducing its leachate potential for the lower depths of refuse (McBean et al, 1995).

Greater concentrations of constituents are found in leachates from deeper landfills under similar conditions of precipitation and percolation. Deeper fills require more water to reach saturation, require a longer time for decomposition, however low moisture content, can result in slow degradation rate extending landfill life, and distribute the leached material over a longer period of time,. Water entering the fill will travel down through the waste. As the water percolates through the landfill, it contacts the refuse and leaches chemicals from the waste. Deep landfills offer greater contact time between the liquid and solid phases which increases leachate strength (FCSHWM, 1998), the chance of dissolving more materials will increase with increase contact time between water and solid waste and this happens in the real life with depth increase, on other word leachate streangth increase as depth of the land fill increase.

2- Age of Landfill

Leachate quality is greatly influenced by the length of time which has elapsed since waste placement. The quantity of chemicals in the waste is finite and, therefore leachate quality reaches a peak after approximately two to three years followed by a gradual decline in ensuing years (FCSHWM, 1998).

Generally, leachate from new landfills will be high in BOD and COD and will then steadily decline, leveling off after about 10 years. All contaminants do not peak at the same time. Due to their initially biodegradable nature, organic compounds decrease more rapidly than inorganic with increasing age of the landfill. Inorganic are only removed as a result of washout by infiltrating rainwater (FCSHWM, 1998).

3- Waste Composition

Municipal waste has great variation in composition and characteristics. The waste composition of refuse determines the extent of biological activity within the landfill. Rubbish, food and garden wastes, and crop and animal residues contribute to the organic material in leachate. Inorganic constituents in leachate such as calcium, magnesium, sodium, potassium, iron, chloride, are often derived from ash wastes and construction and demolition debris. Due to the variability of solid waste, only general assumptions can be made about the relationship between waste composition and leachate quality (FCSHWM, 1998).

4- Moisture Availability

Water is the most significant factor influencing waste stabilization and leachate quality (FCSHWM, 1998).

Moisture addition has been demonstrated repeatedly to have a stimulating effect on methanogenesis, although some researchers indicate that it is the movement of moisture through the waste as much as it is water addition that is important. They stated that high moisture flow rates can flush soluble

Organics and microbial cells out of the landfill and in such cases microbial activity plays a lesser role in determining leachate quality. Also, high moisture application rates can remove the majority of waste contaminants. Under low flow rate conditions, anaerobic microbial activity is the significant factor governing leachate organic strength (FCSHWM, 1998).

5- Available Oxygen

The quantity of free oxygen in a landfill dictates the type of decomposition (i.e. anaerobic or aerobic). Aerobic decomposition occurs during initial placement of waste, while oxygen is available. Aerobic degradation may continue to occur at, and just below, the surface of the fill (FCSHWM, 1998).l.

Chemicals released as a result of aerobic decomposition differ greatly from those produced during anaerobic degradation. During aerobic decomposition, microorganisms degrade organic matter to CO2, H2O, and partially degraded residual organics, producing considerable heat. High concentrations of organic acids, ammonia, hydrogen, carbon dioxide, methane, and water are produced during anaerobic degradation. Phase changes occur in the fill as a result of reductions in the quantity of oxygen in the landfill. For example, a transitional change takes place when oxygen is depleted and an anaerobic environment develops (FCSHWM, 1998).

6- Temperature

Landfill temperature, a largely uncontrollable factor influencing leachate quality, has been shown to fluctuate with seasonal ambient temperature variations. Temperature affects bacterial growth and chemical reactions within the landfill. Each microorganism possesses an optimum growth temperature, and any deviation from that temperature will decrease growth due to enzyme deactivation and cell wall rupture. Solubility of many salts NaCl increases with temperature. However, a number of compounds in leachate, such as $CaCO_3$ and $CaSO_4$, show a decrease in solubility with increasing temperature (FCSHWM, 1998).

7- Landfill design in its operation, (Processed Waste)

Shredding or baling of waste can greatly affect leachate characteristics. Leachate from shredded waste is more highly contaminated during early stages of waste stabilization and less contaminated during later phases than leachate from unshredded waste also agreed that leachate from shredded fills has significantly higher concentrations of pollutants than leachate from unshredded landfills (FCSHWM, 1998).

This higher strength leachate can be attributed to increased surface area and, consequently, increased rates of biodegradation in shredded waste landfills

unshredded waste baling resulted in large volumes of dilute leachate and waste required alonger period to stabilize (FCSHWM, 1998).

2.1.6 Data on leachate composition

Table (4): Typical data on the composition of leachate in landfills

Constituent	Value, mg/l		
	New landfill " less than 2 years" Rang	Typical	**Mature landfill** "greater than 10 years"
BOD_5	2,000-30,000	10,000	100-200
COD	3,000-60,000	18,000	100-500
TSS	200-2,000	500	100-400
Nitrate	5-40	25	10-10
Phosphorous	4-80	20	4-8
Alkalinity	1,000-10,000	3,000	200-1,000
pH	4.5-7.5	6	6.5-7.5
Total hardness	300-10,000	3,500	200-500
Calcium	200-3,000	1,000	100-400
Magnesium	50-1,500	250	50-200
Potassium	200-1,000	300	50-400
Sodium	200-2,500	500	100-200
Chloride	200-3,000	500	100-400
Sulfate	50-1,000	300	20-50
Total iron	50-1,200	60	20-200

(Tchobanoglous, 2002)

2.1.7 Bioreactor Landfill

Phases of Waste Stabilization

Leachate composition is primarily a function of the age of the landfill and the degree of waste stabilization. Numerous landfill investigation studies have suggested that the stabilization of waste proceeds in five sequential and distinct phases (Reinhart et al, 1998).

The rate and characteristics of waste produced and biogas generated from a landfill vary from one phase to another. The rate of progress through these stages is dependent on the physical, chemical, and microbiological conditions developed within the landfill with time (Reinhart et al, 1998).

The waste characteristics associated with the decomposition phases in a landfill are as below (Vaidya, 2002).

Phase I: (Aerobic) after initial placement of waste carbon dioxide and heat produced, temperature rises to approximately 30 ºC, carbon dioxide generated equals oxygen used (timeframe months/up to 1 year) (Vaidya, 2002).

Phase II-III: (Transition-Acid) after onset of anaerobic conditions the carbon dioxide dissolves and results in acidic leachate, numerous organic acids are produced, (time period needed about 1-2 years). The buffering capacity and the available moisture in the waste mass influences the redox conditions and the metals are solubilized by low pH. Hydrogen consumption by anaerobes begins to start and the equilibrium depends on redox conditions, nutrients, temperature and substrate competition between various species (Vaidya, 2002)

Phase IV: (Methane Fermentation) the methanogens consume hydrogen at nearly constant rate and produce methane and carbon dioxide. (time period up to 30 years). Methane potential depends on available substrate, in bioreactor landfills rapid reduction in waste strength is achieved by elevated rate of methane formation and early onset of methanogenesis. Monitoring time frame can be reduced from 30 years to about 3-5 years (Vaidya, 2002).

Phase V: (Maturation) after all the readily bio-degradable waste converted to CH_4 and CO_2 LFG production drops off and is negligible (Vaidya, 2002).

2.2 Literature Review

2.2.1 Introduction

Natural attenuation is the reduction in concentration of contaminants in Ground water by natural processes. These processes can be geochemical and biological, and are dependent on factors such as the cation exchange and sorption capacity of the aquifer material, dilution, the microbial population, the effects of physical heterogeneity of the porous medium (dispersion), microbial carbon sources and nutrients, and the type and quantity of the contaminant to be attenuated. The choice of natural attenuation has become a popular option in recent years, and has been proposed for numerous waste sites.

To evaluate an aquifer's capacity for natural attenuation of groundwater contamination from landfill leachate, the chemical characteristics of the leachate need to be defined from initial generation to some point in the future. Prediction of the changes in chemical characteristics usually requires the use of a quantitative model, and such models should be calibrated to actual data before employed in a predictive mode. Thus, the monitoring of leachate chemistry and evaluation of the data over the life of a landfill is needed to formulate and calibrate models that can make long-term predictions of leachate composition.

As will be discussed in the following section, previous studies conducted to determine the temporal changes in leachate chemistry and others about leachat and its effects.

2.2.2 Solid waste leachate

Study was developed about the characteristics and treatment of leachates from domestic landfills

This study learn that all country make studies on landfills to have data about the leachate e.g. Hong Kong. So Nabluse municipality must have data about MSW leachate from our thesis. Where our thesis work on the special and temporal leachate quality and applied it on the soil, but this study work on the change of leachate quality with time and put the relation of it with phases. This study is different with our study, but our study is need to municipality.

Where the main objectives of that study were to develop a useful database for the leachate quality of Hong Kong landfills, and to compare different experimental trials for the treatment of methanogenic- stage sanitary landfill leachate, which is generally characterized by a low chemical oxygen demand (COD) of 3000 mg L^{-1} or less. Extensive chemical analysis data of leachate composition generated from 10 landfills in Hong Kong were collected to identify variations in leachate quality. Variations in COD and ammonia-nitrogen (NH_3---N) with time revealed that the rate at which Hong Kong landfills become 'methanogenic' is relatively fast. The transition from phase II (where leachates are characterized by high 5-day biochemical oxygen demand values) to phase III (where high organic strength leachates are converted into methane and carbon dioxide) for the landfills in Hong Kong took less than one year. Controlled experimental studies using an aerobic biological treatment process (i.e., sequencing batch reactor) were used to examine its treatment efficiency (Irene, M. C., 1996).

"FCSHWM" by Debra R. Reinhart, D., and Grosh, J., (1998) made a study about analysis of Florida MSW landfill leachate quality

This study learn that leachate quality may be analysis using Microsoft Excel, our analysis similar that work, where our analysis on temporal and spatial leachate quality, but every work done on their landfill.

Current databases for landfill leachates are not geographically specific; rarely acknowledge the impact of site specific parameters such as age, water balance, type of waste, landfill operation, etc. Leachate quality data were acquired for Florida MSW lined landfills from Florida Department of Environmental Protection (FDEP) files. Data analysis was performed using the Microsoft Excel Analysis ToolPak. Analyses were designed to identify trends in the data and to determine the effects of climate, region or location, age of the fill, and waste characteristics on leachate quality.

In general, the Florida climate (e.g. heavy rainfall and warm temperatures) appears to produce dilute leachate. Leachate from shredded waste fills has significantly higher concentrations of organic pollutants than leachate from unshredded landfills.

Kouzeli-Katsiri, A., Bosdogianni, A., and Christoulas, D., (1999) found the prediction of leachate quality from sanitary landfills

This study learn that many country prediction leachate quality from landfill by mathematical model, this is the same aim in our work by applying data on multiple liner regression this is conceder correct if we have huge data. This study is better than our study, which achieves the same aim by different way, our study is simple but has little number of data.

A simple mathematical model was developed to simulate solid waste decomposition in landfills. Two processes were taken into account (1) the exchange of the organic matter between the solid and the liquid phases; and (2) the depletion of the dissolved organic matter due to biological decomposition and flushing. Two equations using first-order kinetics were employed to describe these processes. The landfill was considered as a single fully mixed reactor. The model was calibrated using the results obtained from six pilot laboratory-scale lysimeters. Values for the kinetic parameters are proposed for characteristic types of solid wastes and landfill management practices.

Khoury, R., and El-Fadel, et al., (2000), shows the temporal variation of leachate quality in seawater saturated fills

This study learn that salt water could delay MSW biodegradation which effect on leachate quality, so Nabluse municipality if they wanted to biodegradation the MSW they must not put MSW near liquid waste (sewage) which consider salt water.

In this study, a preliminary laboratory-scale experiment was conducted to evaluate the potential effects of seawater intrusion on biodegradation processes and leachate quality. Chemical analysis was performed on leachate samples for a period of 230 days to study the temporal variation of leachate quality in the early stages of refuse decomposition. Leachate samples were collected weekly and several parameters were monitored including pH, COD, TOC, TDS, EC, chlorides, sulfates, orthophosphates, nitrates, hardness, and heavy metals. Chemical concentration levels were related to biological activity within the test cells, and the results indicated that salt water could delay MSW biodegradation (where the salt inhibition the work of enzyme, and kill the microorganism. In the paste the salt consider way in save the food for long time. So when put salt water on MSW, salt reduce the biodegradation of MSW as the result that the main content of the MSW is organic material).

Richard A. Statom, Geoffrey Thyne, and John E. McCray, (2001), studied the temporal changes in leachate chemistry of a municipal solid waste landfill in Florida

This study learns that TDS and other leachate parameter decreasing with time (with water adding) by dilution as our results, then put the relation between “TDS, time” in equation.

This study is about Temporal Changes in Leachate Chemistry of a Municipal Solid Waste Landfill in Florida, USA

This work done by evaluation of 12 years of time-series landfill leachate chemical data from alined cell of municipal waste shows an overall clining trend in major ion chemistry. The leachate chemistry is dominantly composed of Cl, Na, HCO_3 and organic solutes. Data collected after landfill closure (capping) showed an overall reduction of the amplitude of the short -term variations. Iron and manganese levels increased significantly after capping and were exceptions to the overall decreasing trends of the other metal concentrations.

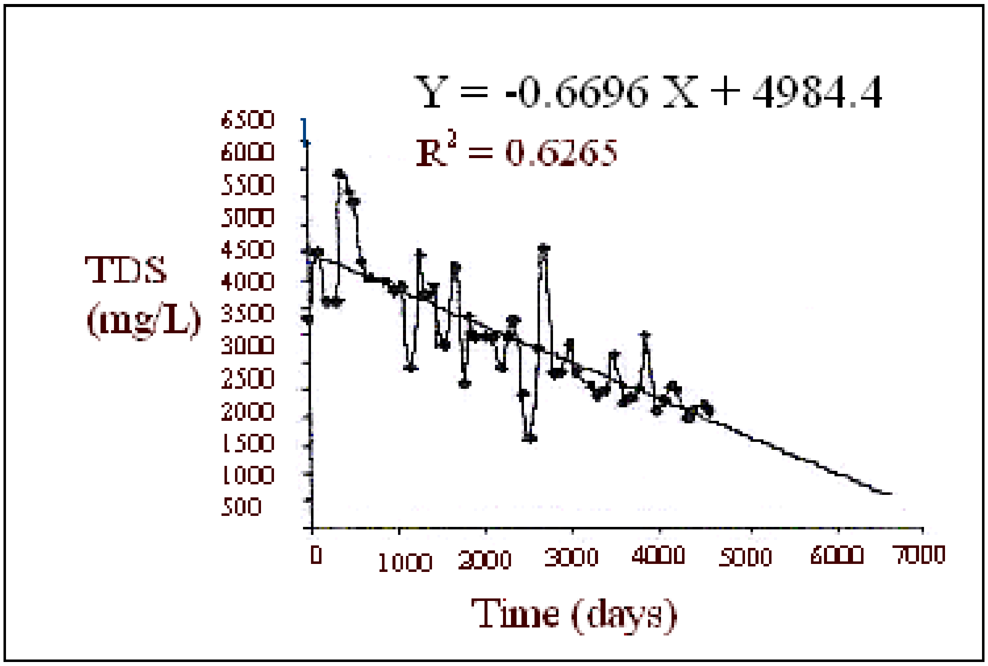

Figure (3): TDS decreasing with time

(Statom, R., etal, 2001)

Weber, W., J., and Jang, Y.C., et al, (2002), studied the leachate from land disposed residential construction waste

This study learn the effect of unlined construction and demolition landfills this done in many country and in our country nearly every construction and demolition landfills are unlined, where its effect on ground water, especially it have high vulnerability to pollution, Nabluse municipality collected the solid waste without distribution on their type, for e.g. MSW with construction and demolition waste.

Solid waste from construction and demolition activities is often disposed in unlined landfills. Leachate from unlined landfills poses a potential risk to groundwater quality. An understanding of the types of chemical constituents likely to be encountered in construction and demolition waste landfill leachate and the concentrations at which they occur help assess this risk. An experiment was performed to characterize leachate from land-disposed residential construction waste. Four 54-m^2 (580-ft^2) test cells were excavated, lined, and filled with waste. Leachate samples were collected and analyzed for a number of water quality parameters over a 6-month period. No volatile or semi volatile organic compounds were detected at elevated constituent levels in the leachate. Inorganic ions were found to account for the bulk of the pollutant mass leached. Calcium and sulfate were the predominant ions in the leachate, resulting from the dissolution of gypsum drywall. The concentrations of several leachate constituents were found to exceed water quality standards. These constituents included aluminum, arsenic, copper, manganese, iron, sulfate, and total dissolved solids.

Al-Yaqout, A. F., and Hamoda, M. F., (2003), showed and evaluated landfill leachate in arid climate

This study learn that the solve of solid waste leachate pollution problem without built lined for land fill, “without built sanitary landfill, only put the solid waste in dump site” this done by choose the suitable place, e.g. Jerico city the that have little quantity of precipitation, so the solid waste put in it, because minimal leachate could be formed in the absence of precipitation.

Generation of leachate from municipal solid waste (MSW) landfill in arid regions has long been neglected on the assumption that minimal leachate could be formed in the absence of precipitation. Therefore, a case study was conducted at two unlined MSW landfills, of different ages, in the state of Kuwait in order to determine the chemical characteristics of leachate. Leachate quality data were collected from both active and old (closed) landfills where co-disposal of MSW and other solid and liquid wastes are practiced. The analysis of data confirms that leachates from both landfills are severely contaminated with organics, salts and heavy metals. However, the organic strength of the leachate collected from the old landfill was reduced due to waste decomposition.

Jang, Y., and Townsend, T., (2003), study the effect of Waste Depth on Leachate Quality from Laboratory Construction and Demolition Debris Landfills

This research study the effect of change the depth of solid waste on leachate quality, our work done on MSW, but this work done on construction and demolition.

Where the landfill leachate quality varies as a function of many factors including waste type, waste depth, time, weather, and landfill operations. A laboratory study was conducted to examine the effect of waste depth on construction and demolition (C&D) debris leachate quality over a period of 365 days. Both single and serial lysimeters were used to simulate leachate from two different C&D debris landfill waste depths. For the serial lysimeter, five individual lysimeters were connected in series; leachate produced from the first lysimeter was pumped into the top of the next lysimeter and so on. The leachate serially flowed through a 6-m depth of C&D debris. An additional single lysimeter with a 1.2-m waste depth was operated by itself. Leachate samples were collected from both lysimeter sets and analyzed for a number of chemical constituents. Although waste depth was demonstrated to play an important role in the chemical composition of leachate from simulated C&D debris landfills, factors such as biological activity and chemical precipitation may also play a major role. Soluble ions (e.g., sodium) increased in concentration at the greater waste depth as the liquid to solid ratio decreased. Some metals (e.g., copper) showed little difference in leachate concentrations between the two different waste depths; concentrations of these metals decreased to below detection limit when reducing conditions became established. The results suggested that sulfate reducing bacteria converted dissolved sulfate from gypsum drywall to sulfide species; many metals are known to precipitate as metal sulfides. The responses of various chemical constituents to increasing waste depth vary as a function of the nature of the contaminants in the leachate as well as chemical and biological conditions in the waste.

Yildiz, E. D., Ünlü, K. and Rowe, R. K., (2004), developed modeling to leachate quality and quantity in municipal solid waste landfills

This research was worked on developed modeling to leachate quality and quantity MSW landfills, this study learn that all country can make studies on leachate modeling, especially Nabluse municipality must have MSW leachate modeling. This study is near with our study, but this study is conceder large study.

The operational phase of landfills may last for 20 years or more. Significant changes in leachate quality and generation rate may occur during this operational period. A mathematical model has been developed to simulate the landfill leachate behavior and distributions of moisture and leachate constituents through the landfill, taking into consideration the effects of time-dependent landfill development on the hydraulic characteristics of waste and composition of leachate. The model incorporates governing equations that describe processes influencing the leachate production and biochemical processes taking place during the stabilization of wastes, including leachate flow, dissolution, acidogenesis and methanogenesis. To model the hydraulic property changes occurring during the development stage of the landfills, a conceptual modeling approach was proposed. This approach considers the landfill to consist of cells or columns of cells, which are constructed at different times, and considers each cell in the landfill to consist of several layers. Each layer is assumed to be a completely mixed reactor containing uniformly distributed solid waste, moisture, gases and micro-organisms. The use of the proposed conceptual model enables the incorporation of the spatial changes in hydraulic properties of the landfill into the model and also makes it possible to predict the spatial and temporal distributions of moisture and leachate constituents. The model was calibrated and partially verified using leachate data from Keele Valley Landfill in Ontario, Canada and from others. Ranges of values were proposed for model parameters applicable for real landfill conditions

Rosqvist, N., Dollar, L., and Fourie, A., (2005), study the preferential flow in municipal solid waste and implications for long-term leachate quality: valuation of laboratory-scale experiments.

This research study the quantify pollutant concentrations after long-term leaching at relatively low flow rates and residual concentrations after heavy flushing of a 0.14 m^3 municipal solid waste sample. Moreover, water flow and solute transport through preferential flow paths are studied by model interpretation of experimental break-through curves (BTCs), generated by tracer tests. In the study it was found that high concentrations of chloride remain after several pore volumes of water have percolated through the waste sample. The residual concentration was found to be considerably higher than can be predicted by degradation models. For model interpretations of the experimental BTCs, two probabilistic model approaches were applied, the transfer function model and the Lagrangian transport formulation. The experimental BTCs indicated the presence of preferential flow through the waste mass and the model interpretation of the BTCs suggested that between 19 and 41% of the total water content participated in the transport of solute through preferential flow paths. In the study, the occurrence of preferential flow was found to be dependent on the flow rate in the sense that a high flow rate enhances the preferential flow. However, to fully quantify the possible dependence between flow rate and preferential flow, experiments on a broader range of experimental conditions are suggested. The chloride washout curve obtained over the 4-year study period shows that as a consequence of the water flow in favored flow paths, bypassing other parts of the solid waste body, the leachate quality may reflect only the flow paths and their surroundings. The results in this study thus show that in order to improve long-term prediction of the leachate quality and quantity the magnitude of the preferential water flow through a landfill must be taken into account.

Mishra, P., Behera, P., and Patel, R., (2005), showed the Contamination of water due to major industries and open refuse dumping in the steel city of Orissa.

This study talks on the real effect of solid waster that made our work near it. That is, contamination of ground water is common in the areas surrounded by industrial refuse dumping sites and the probability of contamination is more where dumping is done in low lying areas and the rate of percolation through the soil is high. In order to assess the ground water pollution by leachate around the refuse dumping site, eighteen wells were selected for study. Few wells are nearer to the dumps, few are far away and others are in between. Also an attempt has been made to evaluate the effect of industrial effluents on the ground and surface water due to Integrated Rourkela Steel Plant and other major industries. From the analytical data of physico-chemical parameters, it is indicated that the river water is contaminated mainly due to the industrial and municipal effluents and the ground water of some of the analyzed areas is contaminated due to municipal and industrial solid waste dumping.

Shao, L., He, P., Zhang, H., Yu, X., Li, G., (2005), study about methanogenesis acceleration of fresh landfilled waste by micro-aeration.

When municipal solid waste (MSW) with high content of food waste is landfilled, the rapid hydrolysis of food waste results in the imbalance of anaerobic metabolism in the landfill layer, indicated by accumulation of volatile fatty acids (VFA) and decrease of pH value. This occurrence could lead to long lag time before the initiation of methanogenesis and to the production of strong leachate. Simulated landfill columns with forced aeration, with natural ventilation, and with no aeration, were monitored regarding their organics degradation rate with leachate recirculation. Hydrolysis reactions produced strong leachate in the column with no aeration. With forced aeration, the produced VFA could be effectively degraded, leading to the reduction in COD of the leachate effluent since the week 3. The CH4 in the landfill gas from the column with aeration rate of 0.39 m3/(m3 x d) and frequency of twice/d, leachate recirculation rate of 12.2 mm/d and frequency of twice/d, could amount to 40% (v/v) after only

20 weeks. This amount had increased up to 50% afterward even with no aeration. Most of COD in the recirculated leachate was removed. Using natural ventilation, CH4 could also be produced and the COD of the leachate effluent be reduced after 10 weeks of operation. However, the persistent existence of oxygen in the landfill layer yielded instability in methanogenesis process.

Sponza, D. T., and Ağdağ, O. N., (2005), showed the effects of shredding of wastes on the treatment of municipal solid wastes (MSWs) in simulated anaerobic recycled reactors

This study to see the effect of the process of solid waste e.g. compacted, shredded or normal solid waste on leachate quality. Learn that the suitable process for the solid waste on landfills to have the pest protection to the environment.

It was observed that waste shredding reduced the waste quantity, the organic content of the solid waste and the biodegradation time.

In this study, the effects of shredding on the anaerobic treatment of domestic solid waste and leachate characteristics were investigated in three simulated landfill anaerobic bioreactors. All of the reactors were operated with leachate recirculation. One of them was loaded with raw waste (control reactor); the second reactor was loaded with shredded waste having a diameter of 0.5–1 cm (shredded reactor); the third reactor was loaded with compacted waste (compacted reactor) in order to compare the effects of shredding and compaction of solid wastes. The leachate recirculation rate was 300 ml/day in all of the reactors. pH, chemical oxygen demand (COD), volatile fatty acids (VFA), ammonium nitrogen

(NH_4–N) concentrations; total methane gas productions in the leachate samples were regularly monitored. After 57 days of anaerobic incubation, it was observed that the pH, COD, VFA concentrations, and BOD_5/COD ratio in the leachate of shredded reactor were better than the control and compacted reactor. The COD values were measured as 6400, 7700 and 2300 mg/l while the VFA concentrations were 2750, 3000 and 354 mg/l, respectively, in the leachate samples of the control, compacted and shredded reactor after 57 days of anaerobic incubation. The values of pH were 6.88, 6.76 and 7.25, respectively, after anaerobic incubation, respectively in the aforementioned reactors. It was observed that the waste shredding increased the methane percentage in the anaerobic simulated reactor. Methane percentage of the control, compacted and shredded reactors were 36, 46 and 60%, respectively, after 57 days of incubation. It was found that MSWs having small size exhibited fast biodegradation. A BOD_5/COD ratio of 0.44 achieved in the shredded reactor indicated the better MSW stabilization resulting in a high rate than that of compacted and control reactors. It was observed that waste shredding reduced the waste quantity, the organic content of the solid waste and the biodegradation time.

Sanphoti, N., Towprayoon, S., Chaiprasert, P., Nopharatana, A., (2006), Enhancing waste decomposition and methane production in simulated landfill using combined anaerobic reactors.

This study looked on the real effect of the design of leachate recirculation on biodegradation, and effect on leachate quality.

The design of leachate recirculation to enhance municipal solid waste decomposition, methane production and microbial activities was taken into account in this study by using the combined anaerobic reactors of a simulated high organic content landfill reactor and a stabilized fixed film anaerobic reactor. The latter aimed to treat high strength leachate from the simulated landfill reactor before recirculation back to the former reactor. The results showed the possibility to apply this technique to high organic waste landfill where rapid and accumulative acids formed in the leachate were removed and treated by a fixed film anaerobic reactor. In addition, the treated leachate when circulated back to the simulated bioreactor landfill helps accelerate waste decomposition and methane production by providing buffer capacity as well as diluting organic content in the leachate to achieve the favorable conditions for acidogen and methanogen, respectively, to rapidly enter into the methanogenesis phase.

2.2.3 Application of solid waste leachate on soil

It was showed the investigation of municipal waste leachate in the unsaturated zone of red soil

This study to see the behavior of leachate transport phenomena in the unsaturated zone. As a result to see organic pollutants in the monitoring wells at Taichung sanitary landfill. The objectives of this study were to understand the leachate transport phenomena in this specific site, to identify the parameters, and to simulate the mathematical transport model of organic matters of leachate plume. Consequently, this study investigated not only the parameters of convection but also the parameters of dispersion, and decay. The results showed that chloride is a good tracer and mercuric chloride is an excellent inhibitor for decay study in this case.

The equilibrium time of soil organic matter's adsorption is less than 12 h. The half life of chemical oxygen demand for the methane phase leachate is 46 d. In the lysimetric study, the experiments simulated field conditions such as soil characteristics and groundwater temperature. The results showed that the mean retardation coefficient is 2.05, and the dispersivity of the column is between 0.17 and 0.35 cm. In addition to the sensitivity study, parameter comparison was made to show Darcy's velocity is the most sensitive parameter (Chen, P. H., and Wang, C. Y., 1997).

Al-Nori, Q., (1999), studied the effect of the chemical quality of the leachate from solid waste on ground water and soil

This study about the effects of the chemical quality of leachate from solid waste on ground water and soil, which learn from it: the way of set up, analysis of leachate and soil, change the elevation of solid waste by but solid waste layers, the long of experiment “time”.

The different between two studies are:

Our work on the special and temporal leachate quality and applied it on the soil, that different with Al-Nori in the type of soil where our experiment soil from Nablus disposal dump site that accumulate solid waste in it throw long time, Al-Nori experiment soil selected from Burqa soil {clay soil) this soil selected from Burqa village where there was a study to build a new landfill for Nablus city and the town around, and used sand soil in this experiment the Gaza soil was use. Other difference in the two works are the parameter that was tested in the leachate and soil.

- Leachate: the samples were analyzed for MSW leachate parameter which are: pH, EC, TSS, TDS, BOD_5, Ca, Mg, Na, K, CO_3, HCO_3, alkalinity, hardness, Sulfate, Phosphate, Nitrate, Cl, and Iron.

- The soil properties which we tested were classified under two different categories; physical and chemical properties.

  - Physical analyses are: pH, EC, sieve analysis, hydrometer test.

  - Chemical analyses are: Nutrition that consists of K, Nitrite, and Phosphorus. Salt source that consists of Na, Ca, Mg, Cl.

But Al-Nori research aimed to study the concentrations and quantities of pollutants (heavy trace metals "Pb, Cd, Cu" in addition to the major anions NO_3, SO_4, CO_3, the organic parameters COD, TOC), for leachate on soil. The following are the main operational parameters used in this model, type of soil (clay, sand, loam), depth of solid waste over soil (one, three, five layers), and rainfall frequency (one, five, ten years).

This study showed that it is acidity of leachate and the major anions SO_4, CO_3. and HCO_3, and the organic parameters TOC, COD, heavy trace metals, Cd, Cu were high and polluted ground water, and caused a large problem for ground water. NO_3, and Pb did not appear in leachate. It also showed that for clay soil when the leachate passing through it from solid waste the EC value, and anions CO_3, HCO_3, SO_4, NO_3, organic parameters COD, heavy trace metals Pb, Cd, Cu were high especially in the surface layer, so this soil is not suitable for agriculture.

The concentration of chemical elements in leachate passing through soil were affected with the type of soil, the concentration passing through sand soil and sandy clay soil were higher than that passing through clay soil. So the concentrations of elements were higher for clay soil than that for sand soil. Where the layer of solid waste over the soil increases, the concentration of chemical elements, organic parameter, and heavy trace metal will increase. When the duration of precipitation increase and the amount of water increases, the concentration of some elements will decreases.

Our study is better than Al-Nori study because our study on real experiment on soil that was polluted from solid waste, and our study behind soil analysis and leachate that passed soil analysis, analyzed the MSW leatchate spatial and temporal, this data that is need to municipality.

Shang, J. Q., and Rowe, R. K., (2003), detected landfill leachate contamination using soil electrical properties

This study learn the effect dissolve solid as indication on contamination that the relation in parallel as increase TDS increase the pollution concentration, where the TDS tested by electric conductivity.

The use of complex permittivity and electrical conductivity to detect soil contamination by landfill leachate is discussed in this work. The electrical conductivity and complex permittivity of a natural clay soil are measured before and after permeation with multiple aqueous ionic solutions (synthetic leachate) that simulate the composition of leachate from a domestic solid waste disposal facility, and with aqueous $CaCl_2$ solutions at various concentrations. The results showed that the experimental system provides reliable measurement of the soil complex permittivity at 250 MHz and of the soil static electrical conductivity. The relative permittivity of soil is shown to decrease linearly with the overall cationic concentrations in the pore fluid, whereas the relative loss factor and electrical conductivity of soil increases linearly with the overall cationic concentration in the soil pore fluid. The cationic species can be distinguished in terms of the different linear regression trend lines of the electrical conductivity, relative permittivity, and loss factor versus ionic concentrations.

VanGulck, J. F., and Rowe, R. K., (2004), found the influence of landfill leachate suspended solids on clog (biorock) formation

This study learn the effect of suspended solids in clogging granular, where the Clogging reduction in drainable porosity and decrease in hydraulic conductivity.

Laboratory column tests were performed to evaluate the role of leachate-suspended-solids in clogging a granular material permeated with Keele Valley Landfill leachate. The development of the clog material was a result of biological, chemical, and physical processes occurring within the column. The precipitated calcium and retention of inorganic suspended solids contributed to the increase in clog inorganic solids. Over the duration of the experiment, 3.7 times more calcium was precipitated in the column (due to acid fermentation) than was retained with inorganic suspended solids. Clogging resulted in a greater than 60% reduction in drainable porosity and a six-order magnitude decrease in hydraulic conductivity.

At the end (summary of others works)

- Irene, M. C study, learn that all country make studies on landfills to have data about the leachate e.g. Hong Kong. So Nabluse municipality must have data about MSW leachate from our thesis.

- Khoury, R., and El-Fadel, et al. study, learn that salt water could delay MSW biodegradation which effect on lechate quality,

- Debra R. Reinhart, D., and Grosh, J. study, learn that leachate quality may be analysis using Microsoft Excel, our analysis similar that work, where our analysis on temporal and spatial leachate quality, but every work done on their landfill

- Kouzeli-Katsiri, A., Bosdogianni, A., and Christoulas, D. study, learn that many country prediction leachate quality from landfill by mathematical model, this is the same aim in our work by applying data on multiple liner regression this is conceder correct if we have huge data. This study is better than our study, which achieve the same aim by different way, our study is simple but has little number of data.

- Richard A. Statom, Geoffrey Thyne, and John E. McCray study, learns that TDS and other leachate parameter decreasing with time (with water adding) by dilution as our results, then put the relation between “TDS, time” in equation

- Weber, W., J., and Jang, Y.C., et al study, learn that the effect of unlined construction and demolition landfills this done in many country and in our country nearly every construction and demolition landfills are unlined, where its effect on ground water, especially it have high vulnerability to pollution, Nabluse municipality collected the solid waste without distribution on their type, for e.g. MSW with construction and demolition waste.

-Al-Yaqout, A. F., and Hamoda, M. F. put statement that is minimal leachate could be formed in the absence of precipitation.

- Jang, Y., and Townsend, T. research study, the effect of change the depth of solid waste on leachate quality, our work done on MSW, but this work done on construction and demolition.

- Yildiz, E. D., Ünlü, K. and Rowe, R. K**.**research was worked on developed modeling to leachate quality and quantity MSW landfills

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And different in the leachate analysis: the samples were analyzed for MSW leachate parameter which are: pH, EC, TSS, TDS, BOD_5, Ca, Mg, Na, K, CO_3, HCO_3, alkalinity, hardness, Sulfate, Phosphate, Nitrate, Cl, and Iron.

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Chapter Three

Methodology

3.1 Study Area

The Study Area– Nablus

The city of Nablus is one of the oldest in the world and has been a place of habitation for 4000 years. Nablus is considered the main business and residential center of the northern region of the West Bank. Nablus is the largest city in the West Bank in terms of number of population.

3.1.1 Location, population and land use

The total district is populated with 349 thousand inhabitants including refugee camps and villages, while Nablus City inhabitants are about 139 thousands (PCBS 2005). The number of Nablus population constituted 13.89% of the total number of the West Bank population and 8.9% of the total number of Palestine population (PCBS 2005). The total area of Nablus city is 28.5 square kilometers (PNIC 2004).

Nablus district is located in the northern part of the West Bank. It bounds by Jenin from the north, Tulkarm from the west, Ramallah and Jericho from the south and the Jordan River from the east (see Figure 7). The district is located between 349m below sea level and 918m above sea level (ARIJ, 1996). Nablus district, has main distinctive major land uses, these include the Palestinian built up area, Israeli settlements, nature reserves, forests as well as cultivated area (Al-Habash, 2003).

3.1.2 Climate

Nablus district has hot, dry summers and moderate rainy winter. The geographical position of Nablus district in the northern part of the West Bank gives it a comparatively lower temperature range than the other districts. During January, the coldest month, the average maximum temperature reaches 13.1°C, and average minimum temperature reaches 6.2°C. During August the hottest month, the average maximum temperature is 29.4°C and the average minimum temperature is 19.5°C. Rainfall in Nablus district is limited to the winter and the spring months, from October to May. The annual mean rainfall is 663.6 mm. nearly 81% of the annual rainfall occurring between December and March, while July is totally dry (Al-Nori, 1999).

3.1.3 Solid waste

Waste generated in the Nablus area range from the materials which are discarded in household dustbins to the by-products of industrial, chemical and agricultural activities.

Proper solid waste management is one of the biggest environmental problems in the district. For example, types of refuse produced in Nablus city are brought to an uncontrolled dumping, located in an industrial area approximately 6.5 kilometers from the city (Nablus Municipality, 2000).

Solid waste in Nablus City

The total amount of solid waste is 168 ton collected from Nablus itself, and another 9 tons from a few (unidentified) villages.

The percapita generation of waste is 1 kg in the city, while in the rural area is 0.6 kg/day, so the weighted average is 0.95kg/day/cap.

The components of Municipal solid waste at Nablus city are shown in Table 4.

Table (5): Composition of MSW at Nablus city dump site

Component sample	**Percent %**
Organic	64.8
Cardboard	8.2
Paper	1.9
Synthetics	2
Textiles	6.1
Plastics	1
Cans	1.8
Glass	5.7
Wood	3
Demolite	2.5
Animal waste	1.5
Agriculture waste	1.5

(Nabllus Municipality, 2000)

Projection of Wastes Generation

With the improvement of the living standards, the per capita contribution will increase. The rate commonly used in Israel is 1.5% compounded for urban population and 2% for rural population. The rural population accounting for 20% of the overall, the rate average of growth will be 1.6%, as table (# 6) (Nabllus Municipality, 2000).

Table (6): Projection of wastes generation

Urban Sector				**Agricultural Sector**			
Year	Pop	Waste	Total Waste	Pop	Waste	Total Waste	Grand total
	10^3	Kg/cap/d	T/yr	10^3	Kg/cap/d	T/yr	Ton/yr
2000	160	1	48,000	40	0.6	7,000	55,000
2010	225	1.15	78,000	58	0.75	13,000	91,000
2015	267	1.25	100,000	68	0.8	16,000	116,000
2020	318	1.35	129,000	82	0.9	22,000	151,000

(Nabllus Municipality, 2000)

3.1.4 Existing waste disposal system at Nablus city

Large amounts of solid waste accumulated and were left either on the streets or inside houses. This situation resulted in the proliferation of flies, insects, and rodents. Collection and disposal of MSW is done by Nablus Municipality. Although plans for establishing a sanitary landfill for MSW from the Nablus area has been put on hold Nablus can still ship its waste for landfilling in a West Bank area under Israeli control in the Jordan Valley zone. The municipality pays a disposal fee of about US $13 per ton of waste (Halaweh, 2005).

3.2 Experimental Program

The experimental program consists of:

a- Leachate extraction column experiment.

b- Leachate application to soil-column experiment.

c- Leachate extraction of one soil column and application to another soil column.

3.3 Experimental Set-up

This set-up was choose because it is the nearest to the real dump site, the simplest way to model the real dump site, cheapest, and see previous study was done on this set-up eg Qusai Al-Nori, and Inaia mizyed.

Each objective was fulfill by made Leachate extraction column experiment, Leachate application to soil-column experiment.

3.3.1 Leachate extraction column

Leachate extraction from MSW is done by making a model similar to the real life which resembles the real MSW in the dump site, regarding its density and exposure to rainfall. The waste density reaches 0.45ton/m^3 in sanitary landfill after most of it is collected in compacting trucks (Nablus Municipality, 2000).

Municipal solid waste was collected from all places of Nablus disposal industrial area. A quantity of MSW was taken and put in known volume "55kg MSW in 100Liter volume", and found out that real dump site density was 0.55 ton/m$^{3.}$

Mixed the collected MSW which was needed for the experiment distributed it in to four columns that have different elevations.

The theoretical required quantity of MSW at each column is in Table 7.

Where the theoretical quantity of MSW was calculated from the density relationship with the weight and the volume, density = ass/volume

The real dumpsite density of MSW at Nablus disposal was calculated by experiment which was 0.55 ton/m^3, the volume of each column was calculated by multiply the elevation with the cross section of each column, when we have density ton/m^3, and calculate the volume so the theoretical weight of MSW can be calculated.

Table (7): The theoretical quantity of MSW in experiment columns

Column Elevation (m)	Volume of Column (m^3)	MSW density (kg/m^3)	Weight of MSW (kg)
0.5	0.0095	550	5.3
1	0.019	550	10. 5
1.5	0.0285	550	15.6
2	0.038	550	20.9

Leachate extraction columns consist of four columns at different elevation which are 0.5, 1, 1.5, and 2 m, made from solid plastic PVC with 6" in diameter (see Figure 4, and Figure 5), the columns were fixed on a wall. MSW was put on each column at 0.5, 1, 1.5, 2.0 m elevation, after the collection of solid waste and after fixed the experiment.

To allow leachate drainage flow freely without eroding from MSW, a layer of gravel 10cm high was put at the bottom of each column. A screen (metal mesh screen) was also placed below the gravel layer at the bottom end of each column and a plastic bottle was placed under each column to collect drainage water. Water was supplied on the top of each MSW column. The amount of leachate that was passed through each of the MSW columns was calculated from the following equation, which calculate the amount of leachate “that was put in each column”, which depend on precipitation, run of coefficient, and evapotranspiration.

L= P (1-C)-E (Phelps, 1996)

Where: L = amount of leachate

P = precipitation

C = run off coefficient

E = evapotranspiration

Leachate in real life is produced from rainfall in winter season, but the experiment was conducted during September and October.

Table (8) : The rainfall and evapotranspiration at winter months

Month	Rain (mm)	E (mm)
December	148	33
January	142	24
February	148	25
March	93	46
	Sum= 531	Sum= 128

(Mizyed, 2000)

C = run off coefficient = 0.15 (Vesilind, 2002)

L= P (1-C)-E

Leachate = 531(1-0.15)-128 = 323.4 mm in winter season.

But rainfall and evapotranspiration in experimental months were in September and October, the quantity of leachate that evapotraspiration in experimental months = 15(1-0.15)-259 = -246.2 mm, this number in minus "quantity of leachate that potential evapotraspiration in experimental months, in summer" means that in summer nearly no rain fall in our country but in summer it have high temperature, on other hand if we have rainfall in September and October the high temperature have potential to evapotranspiration 246.2 mm.

Table (9): Rainfall, potential evapotranspiration at experimental months

Month	Rain (mm)	E (mm)
September	0	140
October	15	119
	Sum =15	Sum = 259

(Mizyed, 2000)

Leachate that must be put in each column = leachate in winter season + quantity of leachate that evapotraspiration in Experimental months.

Leachate depth that must be put in each column = 323.4 + 246.2 = 569.6mm.

Volume of leachate that was passed through each column = cross section area of each column *leachate depth =11 Liters.

For one year precipitation, the amount of one year rainfall was divided by 60 days, because in previous study at Al-Nori thesis study the rainy day at winter season is about (45-60) days (Al-Nori, 1999).

Where this quantity of leachate was distributed in one year, 11 liters of water was distributed to 60 days. In other words, winter season is divided into five parts, and each part consists of 12 rainy days.

Table (10): Quantity of leachate distributed in one year “winter season”

Days distribution (winter season parts)	**Quantity of leachate put in (L)**
First part of winter consists of (12) days	3
Second part of winter consists of (12) days	2
Third part of winter consists of (12) days	2
Forth part of winter consists of (12) days	2
Fifth part of winter consists of (12) days	2

The water that was used as winter rainfall was taken from running municipal of Nablus, which has little difference in chemical concentration with rain water, the source of tap water is ground water that have higher concentration than rain water, so the alternation of rainwater by tap water may increase the concentration of leachate. But when we compare the difference in concentration of rain water and tap water with the MSW leachate the result consider nothing, on other word the little change in concentration between tap or rain water comparing with the very huge concentration in MSW leachate, so the used tap water in place rain water not conceder problem.

This water was added in each column slowly according to their distribution.

3.3.2 Leachate application to soil columns

Leachate that was collected from each MSW column was put on the top of special soil column, where leachate from 0.5m MSW column was put in the 0.5m column of soil, and leachate from 1m MSW column was put in the 1.0m column of soil and so on.

There were 6 soil columns. Each one contains soil from the same Nablus disposal dump site, near the industrial area. The elevation of soil in each column = 2m, the total soil weight in the columns = 204 kg “dump site soil”, which was put in columns after removing the rocks and big stones. Each column also contained mesh wire and gravel.

Then the leachate that was produced from each column of MSW was poured into each soil column, where four columns of MSW were poured into four soil column. The other two columns of soil were used for other purposes which the first column pure rainfall was passed through 2m dump site soil column, in the second one leachate that came out of the 2m soil column was passed through a 1.5m MSW elevation (see Figure 6).

3.4 Onsite Columns Set-up

In this study ten columns were used, and described as follows:-

MSW (1) column: Municipal solid waste 0.5m column from (dump site) was used, leachate was added from one year precipitation, where this leachate quantity was (11) liter, was distributed on 60days.

MSW (2) column: Municipal solid waste 1.0m column from (dump site) was used, leachate was added from one year precipitation, where this leachate quantity was (11) liter, was distributed on 60days.

MSW (3) column: Municipal solid waste 1.5m column from (dump site) was used, leachate was added from one year precipitation, where this leachate quantity was (11) liter, was distributed on 60days

MSW (4) column: Municipal solid waste 2.0m column from (dump site) was used, leachate was added from one year precipitation, where this leachate quantity was (11) liter, was distributed on 60 days

Soil (1) column: Dump site 2m soil column was used, leachate that came out of MSW (1) column was put in it. “The leachate that came out from 0.5m MSW elevation with precipitation one year was put in it, where this leachate was distributed on 60 days”.

Soil (2) column: Dump site 2m soil column was used, leachate that came out of MSW (2) column was put in it. “The leachate that came out from 1.0m MSW elevation with precipitation one year was put in it, where this leachate was distributed on 60 days”.

Soil (3) column: Dump site 2m soil column was used, leachate that came out of MSW (3) column was put in it. “The leachate that came out from 1.5m MSW elevation with precipitation one year was put in it, where this leachate was distributed on 60 days”.

Soil (4) column: Dump site 2m soil column was used, leachate that came out from soil (3) column was put in it. “The leachate that came out of

2.0m dumpsite soil that already came from MSW (3) column with precipitation one year, where this leachate was distributed on 60 days".

Soil (5) column: Dump site 2m soil column was used, leachate that came out of MSW (4) column was put in it. "The leachate that came out from 2.0m MSW elevation with precipitation one year was put in it, where this leachate was distributed on 60 days".

Soil (6) column: Dump site 2m soil column was used, leachate from precipitation of one year without passing through solid waste, where this leachate was distributed on 60 days was added.

3.5 Laboratory Analysis

3.5.1 Leachate

Leachate was collected from each MSW columns and from one soil column. Samples were collected in plastic bottle at the end of every period which was 12 rainy days. Those samples were analyzed in the Water and Environmental Studies Center (WESC) at An Najah National University. The samples were kept in refrigerator. The samples were analyzed for MSW leachate parameter and the same test for the leachate that came out from one soil column. The parameters are: pH, EC, TSS, TDS, BOD_5, Ca, Mg, Na, K, CO_3, HCO_3, Cl, alkalinity, hardness, sulfate, phosphate, nitrate, and iron.

Leachate analysis was conducted according to Standard Methods for the Examination of Water and Wastewater,19th Edition these tests were summarized as table 11 (Eaton et al, 1995),

Table (11): Method of leachate analysis parameter

Parameter	Method
pH	Meter, using HI 8314 Membrane PH meter
EC	Meter, using TH-2400 auto-ranging EC meter.
TSS, TDS	Gravimetric
BOD_5	BOD sensor system FTC 901 Refrigerated
COD	COD reactor and titration
Hardness	Titration
Ca	Titration
Na	Flame Photometer 410,
K	Flame Photometer 410,
Alkalinity	Titration
Cl	Titration
SO_4	Supertonic 21D Spectrophotometer at wavelength 492 nm
NO_3	Supertonic 21D Spectrophotometer at wavelength 570 nm
PO_4	Supertonic 21D Spectrophotometer at wavelength 720 nm
Iron	ASC-701 Shimadzu Atomic Absorption Spectrometer

Leachate analysis:

1- pH value: The pH was measured using HI 8314 Membrane pH meter.

2- Electrical conductivity (EC): EC was determined for the leachate sample every collection using TH-2400 auto-ranging EC meter.

3- TSS: Total suspension solid was determined for the leachate sample every collection by filtrating quantity of leatchate on filtration paper where TSS was collected on filtration paper then dried and TSS concentration in (mg/l) was calculated.

4- TDS: Total dissolve solid was determined for the leachate sample every collection by filtrating quantity of leatchate where the leachate that passed from the filtration paper contain TDS. This leachate was dried, and then TDS concentration in (mg/l) was calculated.

5- BOD_5: Biological oxygen demand for five days (BOD_5) was determined for the leachate samples every collection, used BOD sensor system "FTC 901 Refrigerated" at 20^oC, then BOD_5 in (mg/l) was read.

6- COD: Chemical oxygen demand (COD) was determined for the leachate sample every collection by COD reactor. The sample was put in the COD reactor for two hours at 150^oC, titratied it with Ferous amonum sulfate, where Ferous used as an indicator, then COD in (mg/l) was calculated.

7- Hardness: Total hardness was determined for the leachate samples every collection by titration with EDTA, using the hardness indicator, and then hardness concentration in (mg/l) was calculated.

8- Ca: Calcium was determined for the leachate samples every collection by titration with EDTA, using Ca indicator where pH was adjusted to 12, then Ca concentration in (mg/l) was calculated.

9- Mg: Magnesium was determined for the leachate samples every collection by subtracting the volume of EDTA that was consumed in Ca titration from volume of EDTA that was consumed in total hardness titration, and then Mg concentration in (mg/l) was calculated.

10- Na: Sodium was determined for the leachate sample by Flame Photometer 410, which gives Na concentration in (mg/l).

11- K: Potassium was determined for the leachate sample by Flame Photometer 410, which gives K concentration in (mg/l).

12- Alkalinity: The concentration of the carbonate and bicarbonate was measured by titration of the leachate sample with H_2SO_4, the indicator was phenol phthalin (phph) for carbonate CO_3, and bromo crzol green (BCG) for bicarbonate HCO_3, then alkalinity concentration in (mg/l) was calculated.

13- Cl: Chloride was determined for the leachate sample every collection by titration with $AgNO_3$, using the K_2CrO_4 as indicator, then Cl concentration in (mg/l) was calculated.

14- SO_4: Sulfate was determined for the leachate sample every collection by Supertonic 21D Spectrophotometer type at a wavelength of 492nm.

15- NO_3: Nitrate was determined for the leachate sample every collection by Supertonic 21D Spectrophotometer type at a wavelength of 570nm.

16- PO_4: Phosphate was determined for the leachate sample every collection by Supertonic 21D Spectrophotometer type at a wavelength of 720nm.

17- Iron: Iron was determined for the leachate samples, which were collected from the different periods, and then the iron was determined by ASC-701 Shimadzu Atomic Absorption Spectrometer.

3.5.2 Soil

At the end of the experiment, the soil columns were cut into two parts to take three samples from each column; from the top of the column 5cm depth, from the middle of the column 100cm depth, and from the bottom of the column 200 cm depth. The soil samples were collected in plastic bottles to analyze their parameter in the “Chemical and Biological and Drug Analysis Center”, and in “Soil Lab” at An Najah National University.

The soil properties which we tested were classified under two different categories; physical and chemical properties.

Physical properties are: pH, EC, sieve analysis, hydrometer test.

Chemical properties are:

- Nutrition that consists of “K, nitrite, and phosphorus”
- Salt source that consists of “Na, Ca, Mg, Cl”

Soil analysis was conducted according to Method of Soil Analysis 2^{nd} Ed., (Page et al, 1982).

3.5.2.1 Physical properties

1- pH value: The pH was determined for the saturation paste extract using HI 8314 Membrane pH meter.

2- Electric conductivity: EC was measured as an indication of the total dissolve solids using TH-2400 Auto-ranging EC meter after dilution with water at a ration of 1:5 (soil : water).

3- Bulk density: This was measured by putting a certain weight of soil in certain volume, where bulk density equal mass over volume.

4- Main particle size: by sieving analysis (Das, 1989).

5- Particle-size distribution: sand- silt- clay percentage test can be conveniently done using the hydrometer method. This method includes soaking an oven-dried soil sample in a sodium hexa-meta-phosphate solution over night, then monitoring the changes in specific gravity of the solution with time at constant temperature. The specific gravity is related to the quantity of the suspended particles in solution. The specific gravity of the solution can be used to calculate the mean particle size of the suspended particles (Das, 1989).

3.5.2.2 Chemical composition

Soil content of the chemical elements was determined by extracting it from the solid phase (soil) into a liquid phase (solvent).

The extracting method differs from one element to another. However, many elements can be measured from the saturation extract. The saturation paste is prepared by adding distilled water to weighted amount of soil with known water content. The mixture is stirred then left few hours to allow soil to imbibe the water. More distilled water is added until a uniform saturated soil-water paste is achieved.

The paste solution is then filtered through a Buccaneer filtration funnel under vacuum pressure (Page et al., 1982). The filtration paper used was Whattman No.42 which is classified as medium speed filtration paper.

The chemical elements which are:

1- Sodium and Potassium: The available concentrations of these elements in soil were measured by extracting them from soil using ammonium acetate buffer solutions. The filtrate was examined using Flame Photometer 410.

2- Chloride: The concentration of chloride, in saturated extract, was determined by titrating an aliquot with $AgNO_3$, using K_2CrO_4 indicator.

3- Phosphorous: The phosphorous was extracted from soil by burning the soil, and boiling it with H_2SO_4 concentration 9 N , then adjusting the pH=5, Phosphorus reagent was prepared, then the concentration was measured using Supertonic 21D Spectrophotometer type at a wavelength of 720nm.

4- Hardness: The concentration of calcium and magnesium in soil was determined by dissolving the soil in HCl, and then sample was boiled and filtered. The pH of the extract was adjusted to (10) using ammonia-ammonium chloride as buffer.

Then small quantity of Eriochrome Black T indicator was added and the solution was titrated using standard EDTA solution. The determination of calcium concentration was carried out by titrating the same volume as above with EDTA after adjusting the pH to 12 using sodium hydroxide and using Merocside indicator to detect the end point.

5- NO_2: The nitrite in soil was extracted by saturating the soil sample with water then it was stirred and filtrated. The extracted nitrite was determined by supertonic 21D spectrophotometer type at a wavelength of 540nm.

3.6 Data Handling

Excel program was used in stored the data, adding equations and figures, when we have one variable “period of time or MSW elevation” the equations were put by excel program. But when change the two parameters applying multiple linear regretionor equation on Excel program (Haan, 2002).

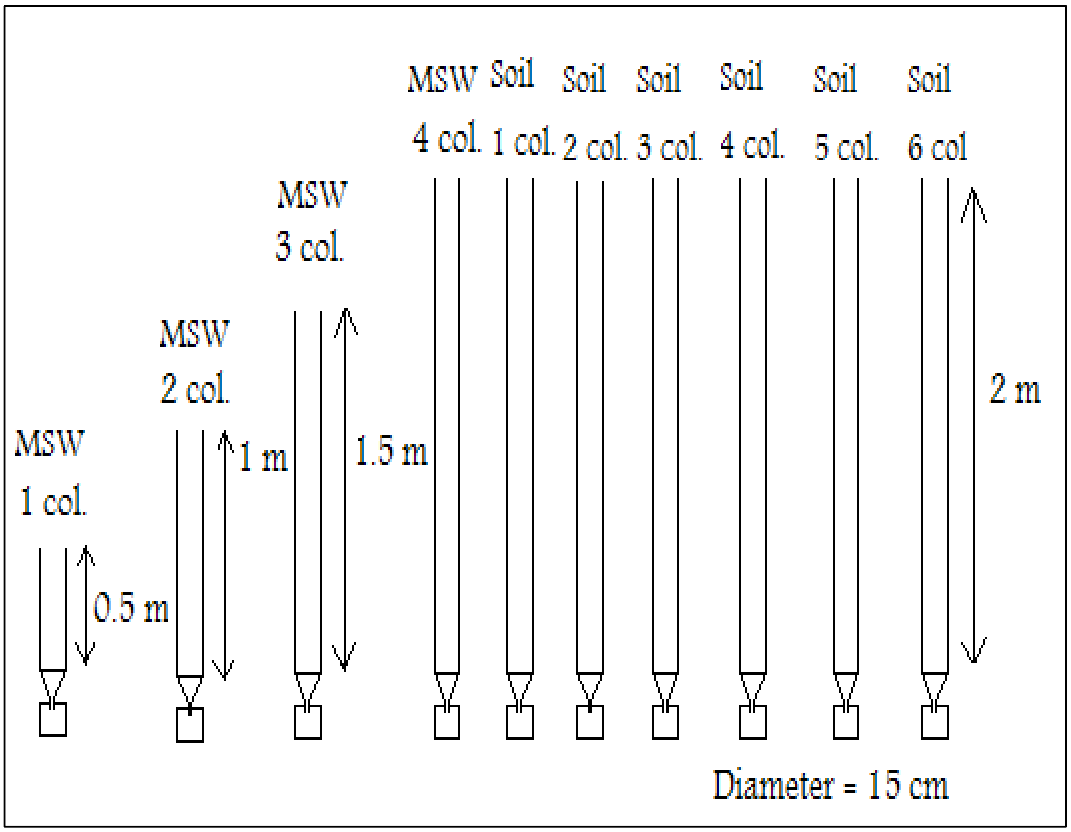

Figure (4): Experiment set up draw

5-**Figure (5):** Experiment set up

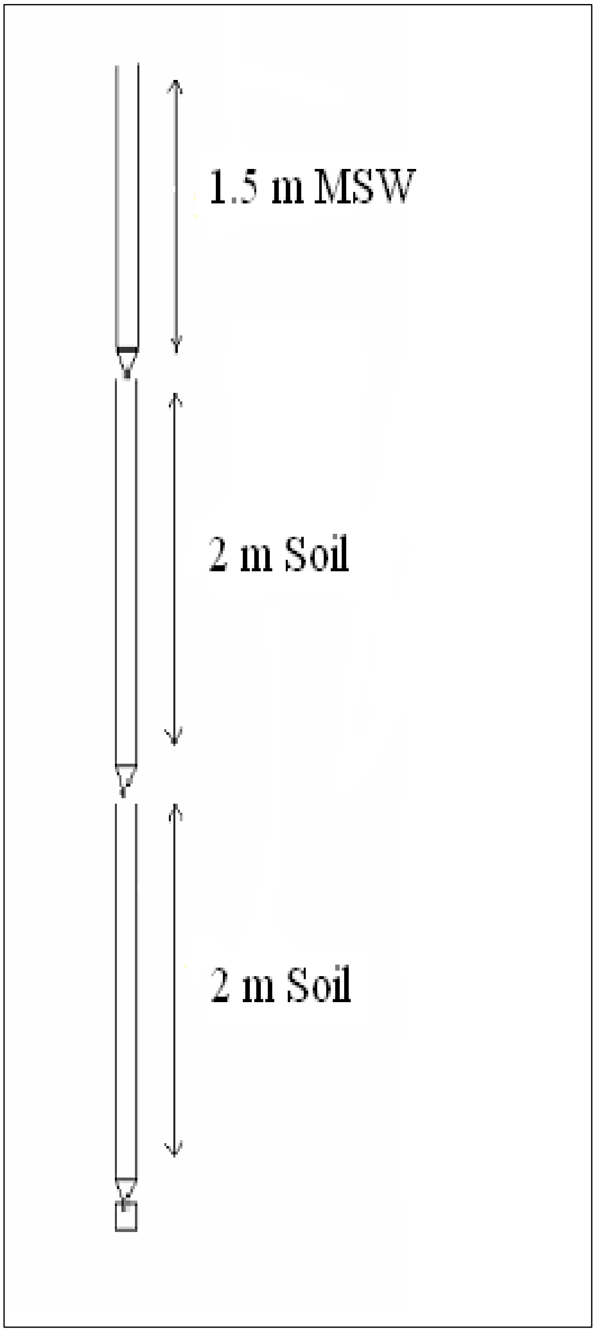

Figure (6): Experiment work

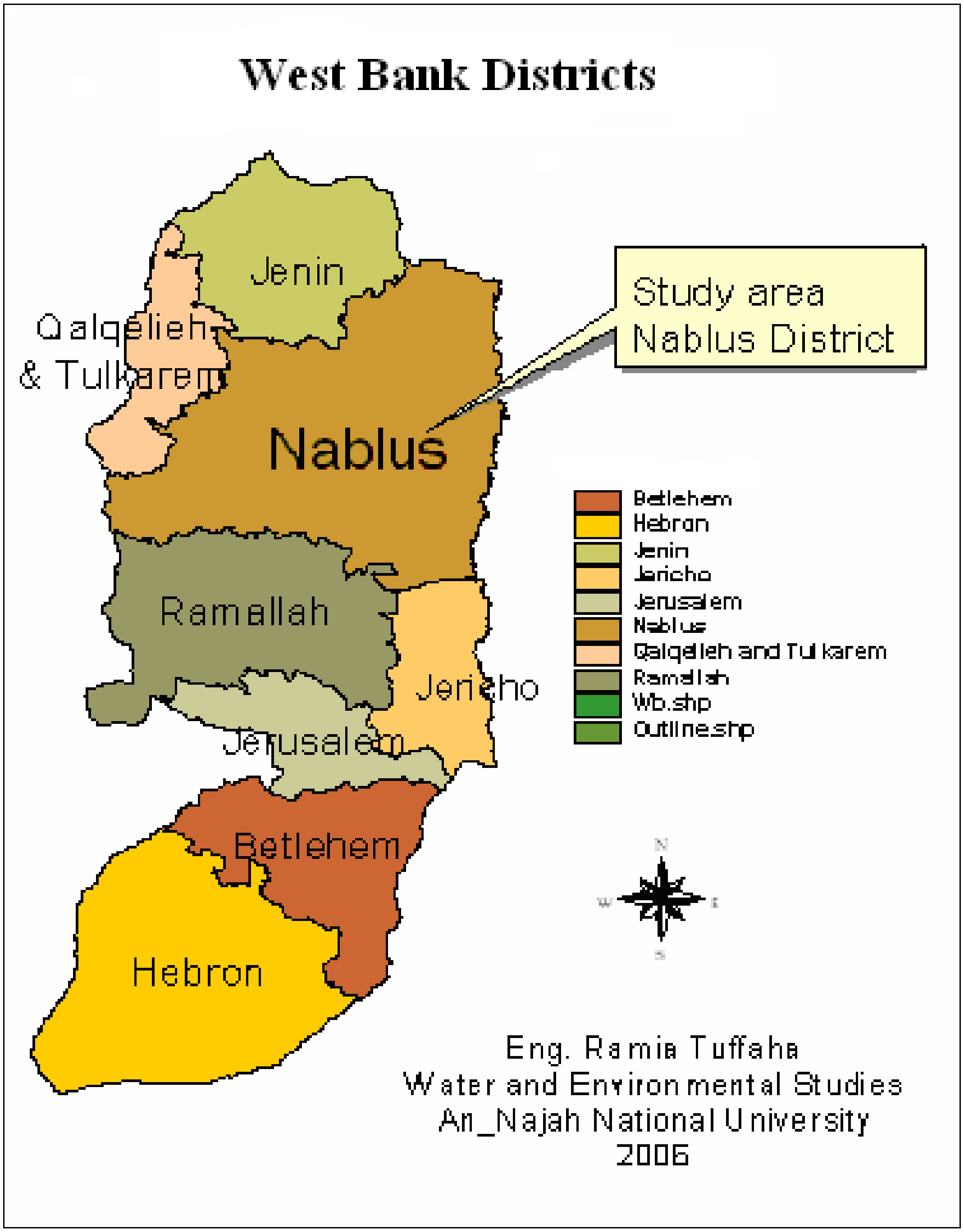

Figure (7): Study area, Nablus district

Chapter Four

Result and Discussion

4.1 Results

The data collected during the analysis of leachate draining out from MSW columns sprayed with rain water, the drained leachate-water flowing out after passing through soil columns, and the soil in various columns are presented and discussed separately in the following sections.

4.1.1 Leachate results

The concentration of elements measured in the leachate collected from the four MSW columns as a function of time (rain water application) and of MSW elevation are presented in Table 12 and Appendix A.

Be attention to the fact that the water was used in the experiment was tap water from municipality, that their chemical analysis were: EC 0.52 ms/cm, TDS 326 mg/l, Cl 59.9 mg/l, alkalinity 200 mg/l, hardness 230.8 mg/l, Ca 60.2 mg/l, Mg 12.5 mg/l, Na 32.4 mg/l, K 2.3 mg/l, SO_4 5mg/l, PO_4 0.02 mg/l, NO_3 18.5mg/l and Iron 0.1mg/l.

The pH of leachate was found to increase with time (less acidity) or with precipitation water added and decrease with MSW depth. This increase is due to the decreasing availability of dissolving solids of and in the same column with time (washing out process) and the increasing availability of those solids with more depth of MSW (accumulation). As the column MSW depth increase the pH of effluent leachate was decreasing (more than one order of magnitude between MSW depth of 0.5 and 2.0 m—after the first water addition). This is clear from the EC, TDS, and TSS values with time and depth (see Figures 8 and 9).

The EC and TDS values almost multiplied as the depth of MSW multiplied but decreased exponentially with time (see Table 12). This general trend was followed with small variations by other measured MSW leachate dissolved constituents such as Cl, BOD, alkalinity, and hardness.

TSS in MSW decreased exponentially with time for the short columns only (see Fig 9) then increasing (and increasing at one point values) as time and depth proceed. This decreasing trend can be explained by that:

- In short columns, TSS leaving MSW as a function of precipitation (water addition and flow) flow out the column quickly and the short MSW have small trapping capacity contrary to deeper columns were TSS leaving the MSW get trapped with MSW depth between subsequent MSW layers (see Figure 9),

- The aerobic/anaerobic nature of processes as the depth increases from 0.5 m to 2.0 m (see Figure 9).

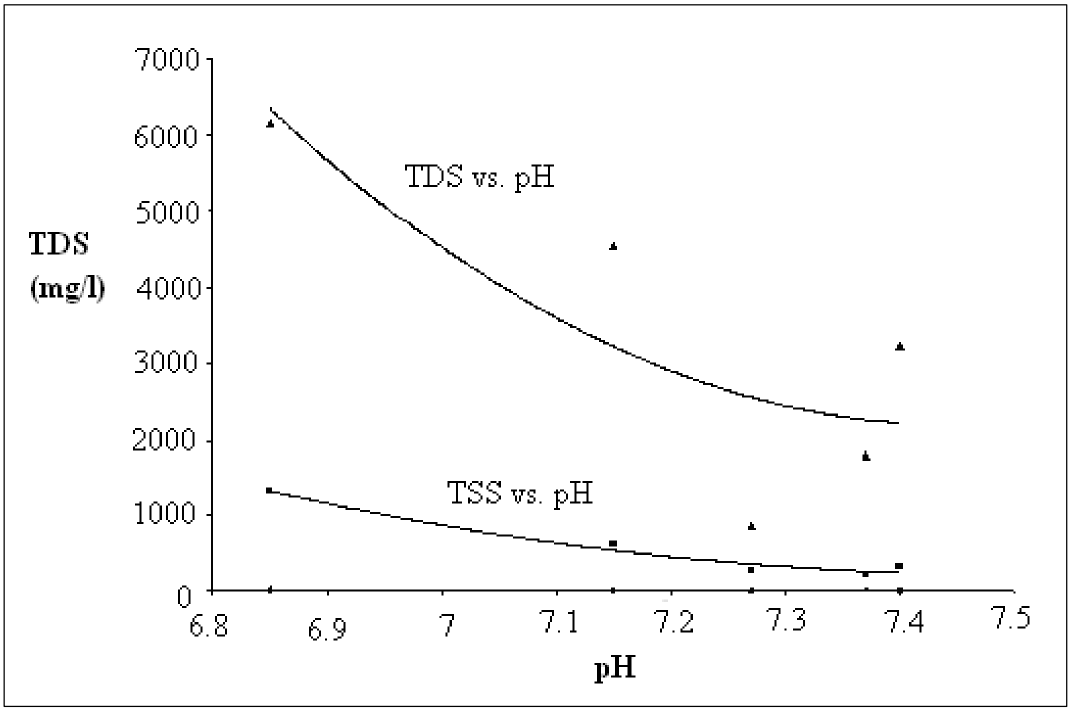

Figure (8): MSW leachate TDS and TSS versus pH

This accumulation of TSS with depth explains the extent of other dissolved constituents as column depth increase: for example the Cl concentration out of 0.5 m column increased by 20% when the depth doubled, then to 170% when the depth tripled, and 220% when the depth increased four times. The BOD concentration out of 0.5 m column increased by 128% when the depth doubled, then to 247% when the depth tripled, and 476% when the depth increased four times.

Following the same phenomenon of TSS accumulation with column depth, hardness and alkalinity (HCO_3) concentrations out of MSW columns were exponentially increased with depth and decreased with time. The concentrations of Ca, Mg, and HCO_3 increased about ten times as column depth increased from 0.5m to 2.0 m.

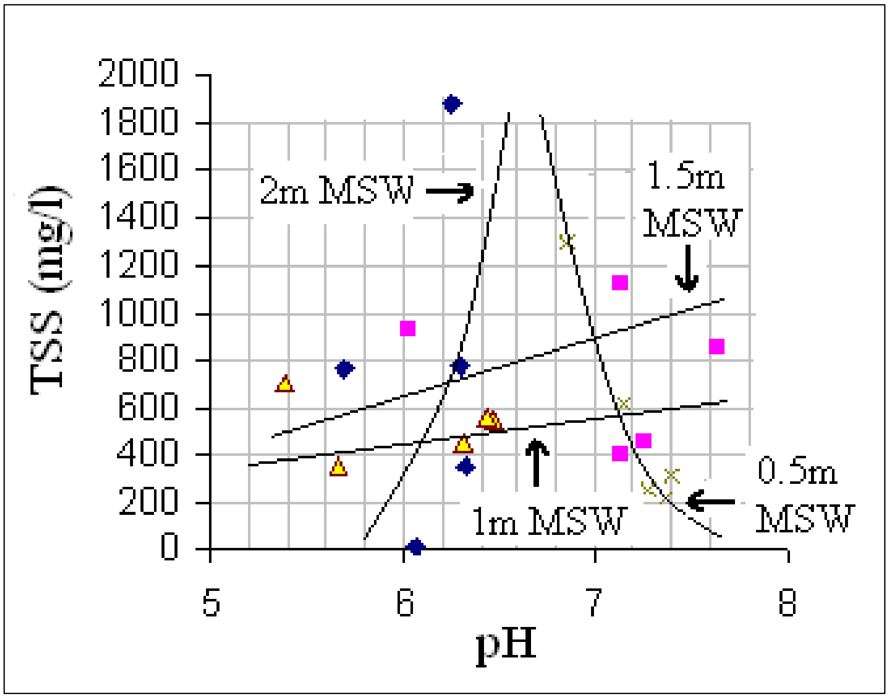

Figure (9): MSW leachate TSS versus pH

The hardness versus alkalinity ratio was about one for the first three additions of precipitation then increased to about 2 after the fourth precipitation addition and then decreased after the fifth precipitation addition. The depletion in Ca and Mg is attributed to bicarbonate dissolution and confirmed with pH change at the same point and apparently occurred due to charge pairing and leaching of those base cations with NO_3 and SO_4 (see Appendix A).

BOD in leachate out of columns was increasing and then decreasing in response to water addition. This trend can be explained by solids accumulation (see Figure 9) and dissolution within the column (see Figure10) or in other words, the increase of total dissolved solids availability in the columns as a response to water addition. In general, the total ion concentration in the leachate was decrease as a function of volume of water added. This process would initially lead to increase in BOD concentrations but with time dilution take place and BOD decompose and BOD decrease with water addition. Figure 10 represent the TDS and BOD versus volume of water added for the 2.0m MSW column.

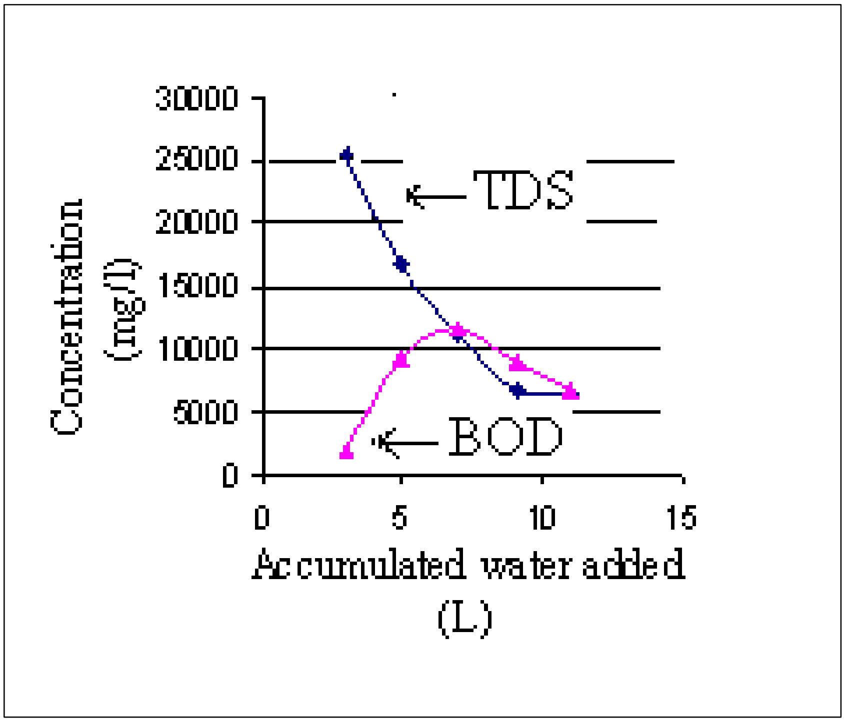

Figure (10): MSW leachate TDS and BOD versus volume of water added

Comparing Na, Ca, Mg, K, and Cl concentrations, lead to the conclusion that the origin of Cl is not only NaCl and KCl, but also $CaCl_2$ and $MgCl_2$ that came from the content of the MSW within the biodegradation.

The potassium concentration is very high and was attributed to the high concentrations of sulphates and phosphates.

The SO_4/Cl ratio was increasing as a function of the amount of water added. This is also due to increase in MSW decomposition with volume of water added (see Figure 11)

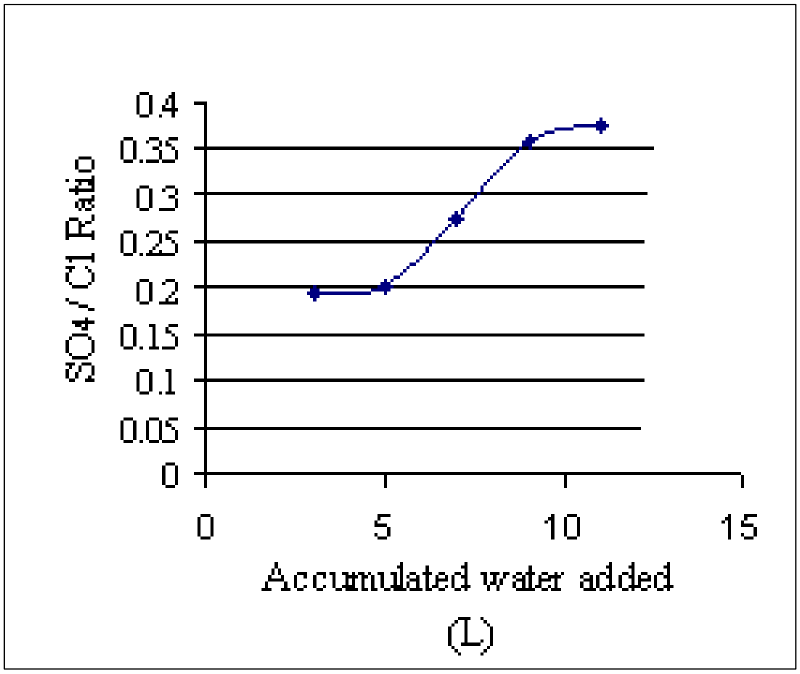

Figure (11): SO_4/Cl ratio versus volume of water added

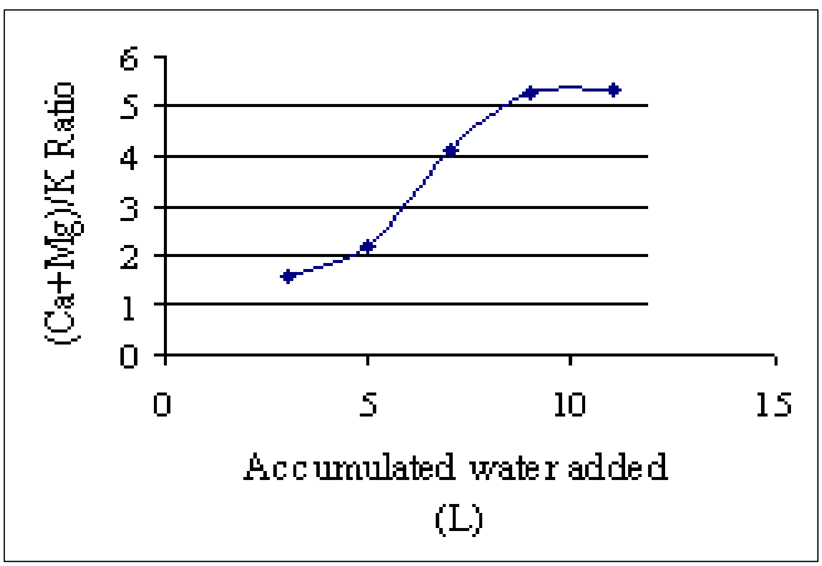

Figure (12): MSW leachate Ca+Mg/K ratio versus volume of water added

In the same manner, Ca + Mg/K ratio was increasing significantly as a function of volume of water added. The ratio indicates high availability of

Ca and Mg minerals and salts in MSW in comparison to K (see Appendix A and Figure 12).

The total ion concentration increase along with the increase in the ratios of SO_4/Cl and Ca + Mg/K are in accordance and agreement with published results of similar experiments (White *et al.*, 1999).

Table (12): MSW leachate with time and Time is winter elevation period = 12 rainy day

pH					EC (ms/cm)			
Time 12 day	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**
1	5.69	6.03	5.39	6.85	22.20	20.50	11.77	7.72
2	6.06	7.13	5.66	7.15	12.12	12.05	6.77	4.37
3	6.25	7.65	6.31	7.40	11.76	11.30	5.62	3.57
4	6.33	7.25	6.47	7.37	7.62	6.83	3.15	1.77
5	6.30	7.14	6.44	7.27	7.55	6.54	2.27	1.42
TSS (mg/l)					**TDS (mg/l)**			
Time 12 day	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**
1	768	920	704	1300	25216	23276	13744	6160
2	628	1120	350	615	16360	11936	7732	4520
3	1880	850	444	312	11260	10215	6388	3204
4	348	446.7	540	220	6608	4660	2560	1776
5	773	395	560	255	6473	4875	1860	860

4.1.2 Leachate out of soil column.

Due to limitations on available laboratory analysis, only the chemical analysis related to leachate coming out of soil column No. 3 (total depth of 2.0 m and receiving leachate from 1.5 m MSW column) were made possible. Measured chemical analysis values of various soil quality parameters are listed in Table 13 and Appendix B.

The pH of leachate out from soil column 3 as a function of leachate added was slightly decreasing. This is probably due to the buffering capacity of the soil.

As expected and shown in Table 13, TSS in the leachate coming out of soil column No.3 was significantly reduced and this is mainly due to the filtering capacity of the soil.

TDS, EC, and Cl of leachate as well as other dissolved constituents increased due to the dissolution of available salts and minerals from the soil. For example, Cl in leachate out was five times that entering the column, Ca and Na increased by five times and Mg increased four times and so forth.

Comparing Ca, Mg, Na and Cl concentration reveal that Chloride source is not only NaCl but also $CaCl_2$ and possibly also $MgCl_2$. These also give an extent of the soil high salt composition at the dump site.

The decreases in Ca concentrations may be attributable to accumulation in the organic and upper mineral soil layers of the column in addition to reaction with available NO_3 and SO_4.

Interesting and contrary to the previous trend, potassium in leachate coming out of the soil column No. 3 was highly reduced. This may be attributed to soil content of K and to the adsorption capacity of the soil. The Ca + Mg/K ratio in leachate coming out of soil column was higher than that of MSW leachate but notably with little variation due to homogenous composition of Ca + Mg in soil in addition to the decreasing availability of K in the soil (see Appendix B and Figure13).

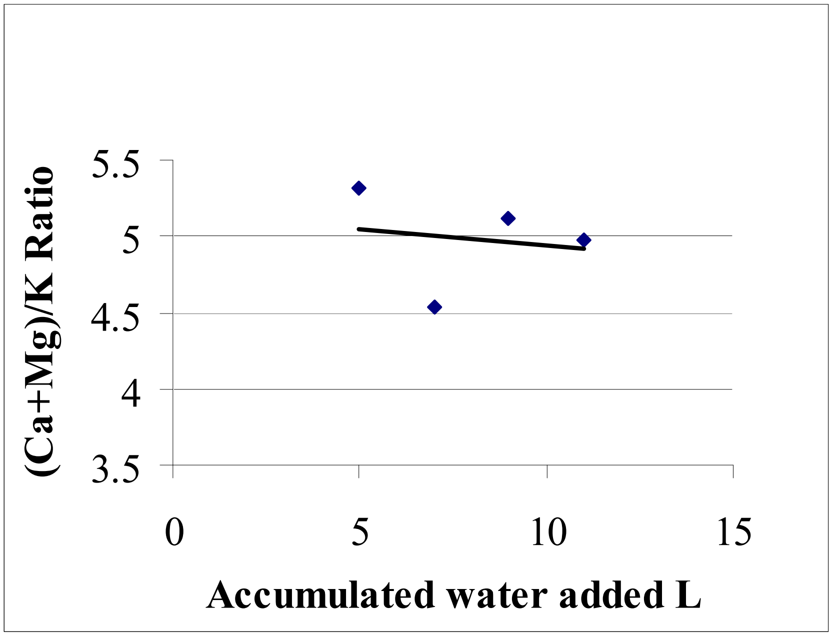

Figure (13): Soil Ca+Mg /K ratio versus volume of water added

Soluble organics (as BOD and/or COD) also decreased in the leachate out of the soil column compared to that entering it. The decrease might be attributed to the bacterial decomposition within the soil in addition to the filtering capacity of the soil. This explanation is supported by that the first point or the measurement after the second addition was increasing due to the short time, not allowing the decomposition to take place.

The SO_4/Cl ratio in soil column leachate was decreasing and at higher water doses increasing. This trend is different than that for the MSW leachate which was increasing with water addition for all water doses. A result that might be attributed mainly to the adsorption of SO_4 in the top layers of the soil. Also to some extent this trend is due to the high Ca as a cation base ion for SO_4.

NO_3 concentrations in soil leachate decreased progressively with water addition due to ion pairing with base cations and accumulation in or within soil layers.

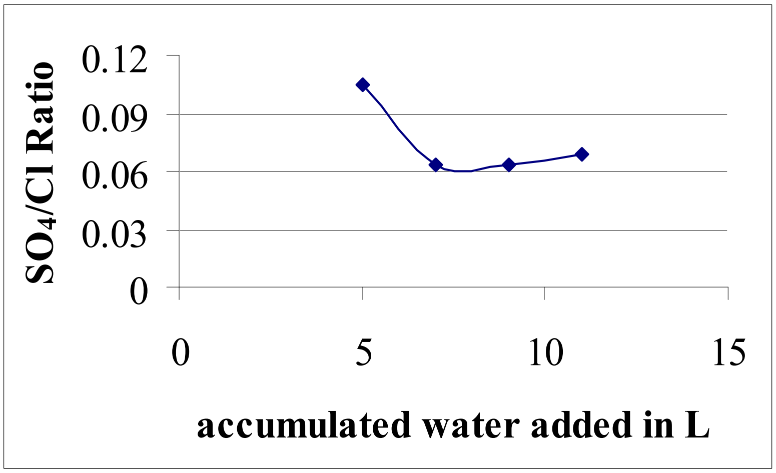

Figure (14): SO_4/Cl Ratio versus volume of water added

Table (13): Leachate that inter and out of soil column # 3

Time 12 day	pH		EC (ms/cm)		TSS (mg/l)	
	IN	Out	IN	Out	IN	Out
1	6.03	-	20.50	-	920	-
2	7.13	7.06	12.05	28.80	1120	596
3	7.65	7.28	11.30	25.30	850	730
4	7.25	7.50	6.83	24.10	447	807
5	7.14	7.70	6.54	23.50	395	315
Time 12 day	**TDS (mg/l)**		**BOD_5 (mg/l)**		**COD (mg/l)**	
	IN	**Out**	**IN**	**Out**	**IN**	**Out**
1	23276	-	1600	-	4800	-
2	11936	43024	7050	3132	9600	6400
3	10215	30860	8740	5880	16000	8000
4	4660	23833	4900	4380	5600	4400
5	4875	20980	4100	1720	4700	2000

4.1.3 Soil characteristics

The results of the effect of MSW leachate on dumpsite soil with soil depth and MSW elevation are given in Table 14 and 16 and Appendix C.

As shown in Table 14, gravel was decreasing and sand was increasing with column depth. The soil texture is sandy and the very high uniformity coefficient (Cu >>5) indicate a very no-uniform soil.

Table (14): Physical characteristic of soil at different depth

Depth of Soil			
Property	**Top (5 cm depth)**	**Middle (100 cm depth)**	**Bottom (200 cm depth)**
Gravel	40.2	35.767	27.200
Sand	59.7	63.867	72.799
(Silt and Clay) fine	0.1	0.3667	0.0013
Texture	Sand	Sand	Sand
D_{50} (mm)	3.2	3.1	2.4
Cu	12	10.5	12.4
Bulk density (ton/m^3)	1.33	1.33	1.33

Where "Unified Soil Classification System" is used to classified particle size (Das, 2002).

The initial content of the soil as it was taken from the dump site location indicates an alkaline soil high in calcium, magnesium, sodium, and chloride ion concentration (see Table 15).

Measured lab analysis of soil columns after receiving a one year load of MSW leachate with different strength are presented in Table 16 and for soil depth of 5, 100, and 200 cm.

SAR of the soil in all columns although increased slightly with depth was excellent (bellow 1.5).

Calcium and Magnesium concentrations in the soils of all columns were almost constant regardless of the strength of the MSW leachate applied. However the top soil was always less in calcium, magnesium, sodium, and potassium content. This is due to that initial cation pool mobilization and depletion begin in upper soil layers and then continue downward through the soil. A result that agree with what was found by White *et al*. (1999)

Soil sodium and chloride concentrations in all columns were increasing significantly with depth. This indicate that irrigating soils with MSW leachate would highly help in treating the leachate and from the SAR values of the soil still very suitable for all kinds of vegetation. Caution should be paid to both leachate composition of toxic and hazardous materials and to long-term effects of salts and solids accumulation (20-50 yrs).

The EC and TDS values determined in the effluents of all six soil columns are presented in Table 16 and appendix C. The EC values for the different treatments ranged between 600 and 3490 μ S/ cm and were significantly higher than those measured in the influent MSW leachate solutions. The differences between influent and effluent EC for each column were consistent for all columns.

The decreases in pH values of soil (see Table 16) to below those of the influent solutions was possibly due to the exchange of hydrogen ion from the soil colloids by cations from the leachate. This decrease is small and is not occurring in all samples analyzed due to the small fraction of clay (see Table 14), soil texture.

Table (15): The chemical concentration elements in the dump site soil

Element	Concentration
pH	8.4
EC	1.245 (ms/cm)
Cl	3.2 (g/kg)
Na	2.2 (g/kg)
Mg	10.3 (g/kg)
Ca	197.4 (g/kg)
PO_4	22 (mg/kg)
K	1.6 (g/kg)

Table (16): The physical and chemical properties of soil with depth**.**

pH						
Soil Depth (cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	8.36	8.65	9.14	8.69	9.03	8.54
100	8.24	8.12	8.32	8.06	8.33	8.53
200	8.45	7.96	8.35	8.69	8.61	9.06
EC (ms/cm)						
Soil Depth (cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	0.602	0.735	0.855	1.460	0.992	0.176
100	0.849	0.963	1.100	1.598	1.250	0.277
200	1.321	1.381	1.432	3.490	1.500	0.475
SAR						
Soil Depth (cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	0.4140	0.6290	0.8875	1.4815	1.0921	0.4030
100	0.6332	0.9720	1.1867	1.2461	1.2445	0.5693
200	0.9760	1.1732	1.3251	1.4962	1.4214	0.7143

4.2 Data Modeling

Statistical analysis of quality data collected showed that responsive functions of elements under consideration using multiple liner regression were possible and adequately acceptable, it conceder more acceptable if have a huge number data. The relationships between the element concentrations under consideration in the column as a function of MSW elevation and volume of water added (or time duration of the rainy days) was found by means of regression analysis using the experimental data obtained in this study, T = Time “winter period =12 rainy day”, E= MSW Elevation in meter.

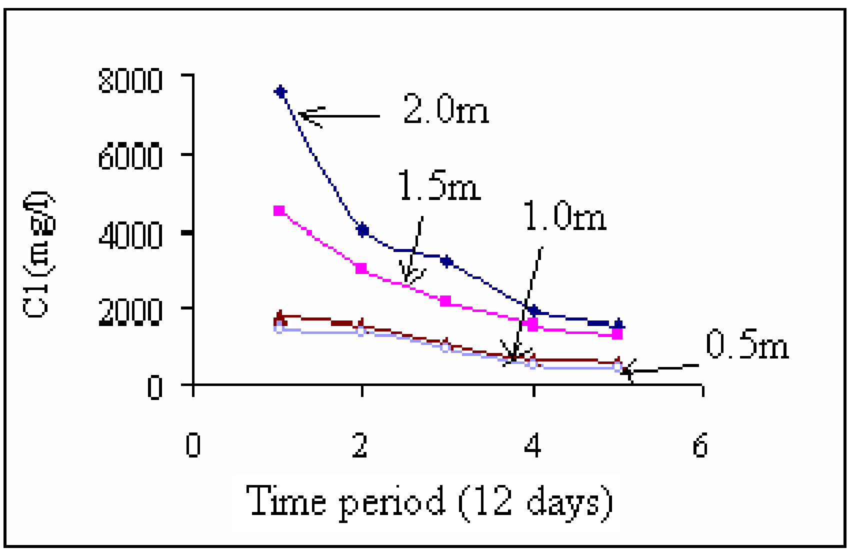

Figure (15): Cl with period of time and MSW elevations

$$Cl = 1818.1055 - 694.3875T + 1877.784E$$
$$R^2 = 0.75131$$

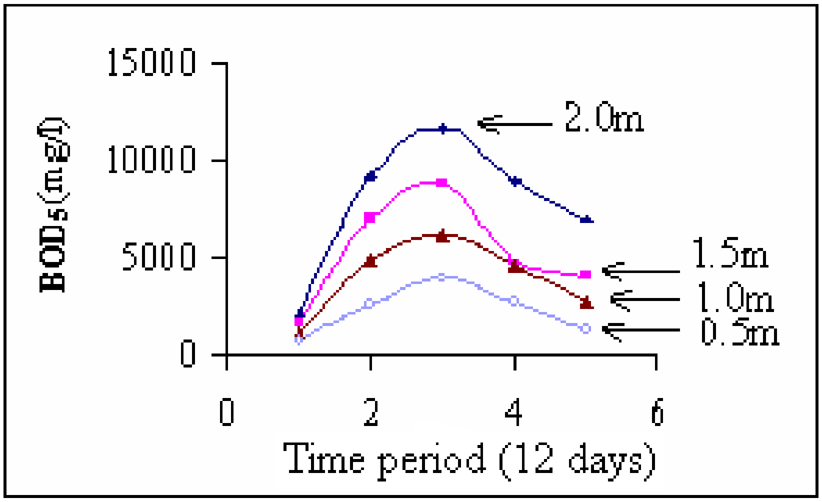

Figure (16): BOD_5 with period of time and MSW elevations

BOD_5 =-893.2+398.4 T+3579.56E
R^2 =0.46424

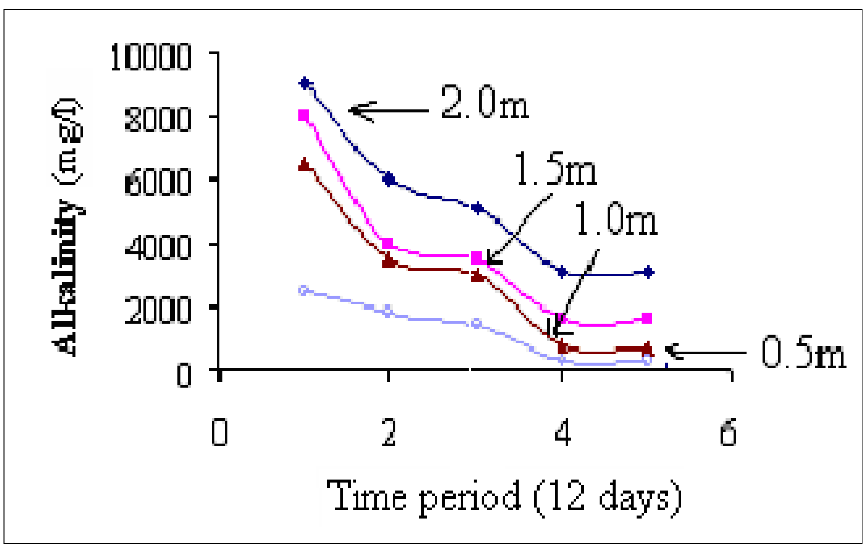

Figure (17): Alkalinity with period of time and MSW elevations

Alkalinity=3837.5-1252.5T+2568E
R^2 = 0.870903

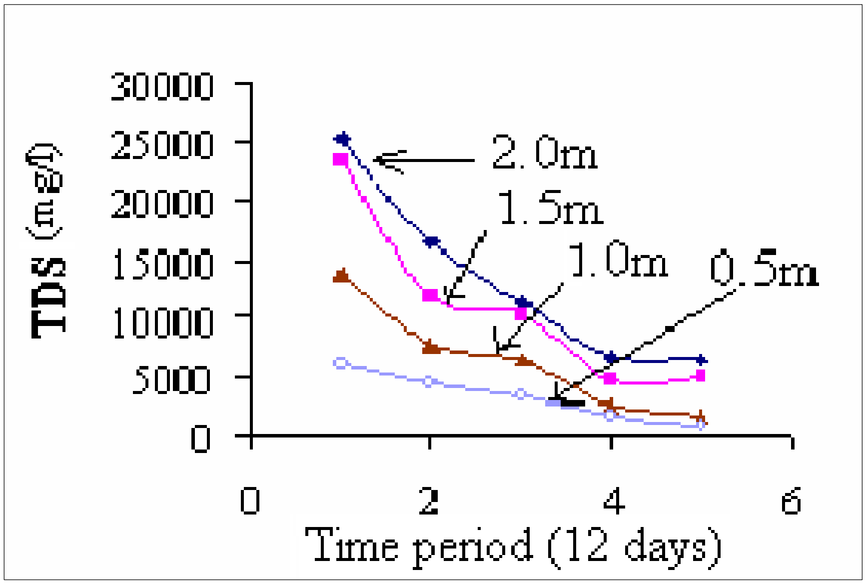

Figure (18): TDS with period of time and MSW elevations

TDS =9960.7-3340T+6834.76E

R^2 =0.836626

Chapter Five

Conclusions and Recommendations

5.1 Conclusions

The results of this study demonstrated that

- TSS and TDS of MSW leachate were increasing with increasing MSW depth and decreasing with increasing volume of water added.
- The concentration of element in the leachate that out from the dumpsite soil was very huge, this reason to the huge quantity of solid waste that put on it through the time.
- The total ion concentration increase along with the increase in the ratios of SO_4/Cl and Ca + Mg/K. The results are in good agreement with published results of similar experiments (White *et al.,* 1999).
- NO_3 concentrations in soil leachate decreased progressively with the increase in volume of water added due to ion pairing with base cations and accumulation in or within soil layers, NO_3 concentrations in leachate that out from the soil column was higher than that in the leachate that out from the MSW.
- SAR values of the soil impacted by MSW leachate and in all columns tested increased slightly with depth but remained within the excellent range of soils suitable for agricultural development.
- Removal of pollutants from MSW leachate by passage through a soil was good. Therefore, soil irrigation with MSW leachate may be an effective purification technique provided that it is practiced with caution, and consideration is given to soil and leachate properties.

- Statistical analysis of quality data collected showed that responsive functions of elements under consideration using multiple liner regression were possible. And acceptable if it built on a huge number of data, so can be used to predict the elements as a function of MSW elevation and extent of precipitation.
- This results achieved first and second objective, but the third objective we recommendation other research to achieved it, because it need computer model.
- This study not solve the leachate problem, but put real data on leachate quality with change parameter and data on the soil quality after put on it MSW, this data must put under municipalities hands.

5.2 Recommendations

Although on the short term, the experimental results of this study did not indicate any extreme or alarming impacts of MSW leachate on soil and groundwater, it is recommended that the experiment be repeated with larger – in the field – site instead of columns and further column and onsite leaching studies be conducted to explore the long-term impacts of MSW.

Another recommendation is that salts and solids accumulated in soils under MSW or exposed to MSW leachate have no impacts on the agricultural quality of the soil and should be vegetated to minimize the extent of those solids and salts in the soil on the long term and also minimize there possible drainage to groundwater.

Appendices

Appendix A

BOD_5 (mg/l)					Cl (mg/l)			
Time 12 day	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**
1	2050	1600	1100	685	7556.3	4504.9	1751.9	1501.6
2	9240	7050	4908	2616	4004.0	3003.3	1601.8	1401.5
3	11660	8740	6160	3880	3253.6	2152.4	1101.2	1001.1
4	8860	4860	4640	2700	1902.1	1601.8	700.8	550.6
5	6800	4100	2700	1180	1601.8	1351.5	600.7	500.6

Alkalinity (mg/l)					Hardness (mg/l)			
Time 12 day	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**
1	9000	8000	6500	2500	5000	4400	3900	1700
2	6000	4000	3500	1800	3200	2500	2000	1400
3	5100	3500	3000	1400	2800	1900	1700	1300
4	3100	1800	800	300	1400	900	800	700
5	3100	1600	700	300	1300	800	500	200

Ca (mg/l)					Mg (mg/l)			
Time 12 day	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**
1	1400	1200	1160	480	364.5	340.2	243.0	121.2
2	880	680	520	400	243.0	194.4	170.1	97.2
3	800	520	480	400	194.4	145.8	121.5	72.9
4	440	260	240	200	72.9	60.8	48.6	48.6
5	400	240	120	40	72.9	48.6	48.6	24.3

SO_4(mg/l)					PO_4 (mg/l)			
Time 12 day	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**
1	837.5	600.0	337.5	312.5	132.20	123.90	112.00	30.11
2	875.0	587.5	325.0	275.0	85.11	75.20	50.77	9.78
3	638.0	550.0	300.0	288.0	69.56	49.89	35.11	8.55
4	450.0	300.0	250.0	225.0	54.66	31.67	19.67	7.44
5	387.5	287.5	225.0	187.5	53.11	19.33	17.22	3.89

NO_3 (mg/l)					Iron (mg/l)			
Time 12 day	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**
1	2.78	2.20	0.95	0.18	16.128	12.097	9.611	2.097
2	2.00	0.67	0.39	0.16	13.372	5.740	5.490	1.410
3	0.46	0.14	0.00	0.00	8.600	4.160	3.802	1.292
4	0.00	0.00	0.00	0.00	5.972	3.781	2.799	0.934
5	0.16	0.00	0.00	0.00	5.531	3.406	1.837	0.191
K (mg/l)					**Na (mg/l)**			
Time 12 day	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**	**2m MSW**	**1.5m MSW**	**1m MSW**	**0.5m MSW**
1	-	-	-	1420	-	-	-	1380
2	2420	1820	1360	825	982	890	805	720
3	-	-	-	350	-	-	-	455
4	-	-	-	170	-	-	-	260
5	-	-	-	148	-_	-_	-_	247

Appendix B

Time 12 day	Ca (mg/l)		Mg (mg/l)		Hardness (mg/l)	
	IN	Out	IN	Out	IN	Out
1	1200	-	340.2	-	4400	-
2	680	3400	194.4	1385.1	2500	14200
3	520	2600	145.8	850.5	1900	10000
4	260	1680	60.8	826.2	900	7600
5	240	800	48.6	801.9	800	5300
Time 12 day	**PO_4 (mg/l)**		**NO_3 (mg/l)**		**SO_4 (mg/l)**	
	IN	**Out**	**IN**	**Out**	**IN**	**Out**
1	123.90	-	2.20	-	600.0	-
2	75.20	7.77	0.139	19.58	587.5	2087.5
3	49.89	0	0.140	8.10	550.0	850.0
4	31.67	0	0	3.76	300.0	800.0
5	31.67	0	0	1.16	287.5	725.0
Time 12 day	**Cl (mg/l)**		**Alkalinity (mg/l)**		**Iron (mg/l)**	
	IN	**Out**	**IN**	**Out**	**IN**	**Out**
1	4504.9	-	8000	-	12.097	-
2	3003.3	20022	4000	5000	5.740	11.267
3	2152.4	13515	3500	4300	4.160	8.757
4	1601.8	11513	1800	3400	3.781	8.368
5	1351.5	10512	1600	3000	2.915	6.774

Time 12 day	K (mg/l)		Na (mg/l)	
	IN	Out	IN	Out
1	3132	-	1705	-
2	1820	900	890	5010
3	772	761	562	4375
4	375	490	305	3910
5	120	322	236	3660

Appendix C

Ca (mg/kg)						
Soil Depth(cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	174.4	176.0	179.2	217.6	184.0	92.8
100	184.0	193.6	201.6	224.0	203.2	131.2
200	192.0	204.8	211.2	228.8	212.8	184.0
Mg (mg/kg)						
Soil Depth(cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	3.84	5.76	9.60	11.52	9.60	4.80
100	8.64	7.68	6.72	14.40	8.64	7.68
200	11.52	12.48	14.40	13.44	16.32	11.52
Na (mg/kg)						
Soil Depth(cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	640	985	1425	2620	1775	465
100	1025	1605	1990	2255	2110	785
200	1630	2025	2335	2725	2530	1170
Cl (mg/kg)						
Soil Depth(cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	443.8	985.4	2028.6	2262.5	2150.4	355.0

100	887.5	1450.5	2218.8	3042.5	2410.3	532.5
200	1972.2	2153.5	2535.7	3550.0	2680.8	710.0
PO_4 (mg/kg)						
Soil Depth(cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	15.43	32.85	58.53	18.35	74.75	3.27
100	11.68	20.95	30.03	12.53	49.51	3.93
200	8.41	15.24	19.84	7.32	28.47	1.25
NO_3 (mg/kg)						
Soil Depth(cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	0	0	0	130	0	0
100	49	0	80	210	20	50
200	0	0	90	230	70	120
K (mg/kg)						
Soil Depth(cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	950	1194	1586	2225	1710	445
100	1090	1370	1875	1630	2020	860
200	1815	1895	2010	1495	2450	950

TDS (mg/kg)						
Soil Depth(cm)	**Col #1**	**Col #2**	**Col #3**	**Col #4**	**Col #5**	**Col #6**
5	385.3	470.4	547.2	934.4	634.9	112.6
100	543.4	616.3	704.0	1022.7	800.0	177.3
200	845.4	883.8	916.5	2233.6	960.0	304.0

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جامعة النجاح الوطنية
كلية الدراسات العليا

تأثير عصارة المخلفات الصلبة على التربة والمياه الجوفية

إعداد
رامية بسام رضا تفاحه

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قدمت هذه الأطروحة استكمالا لمتطلبات درجة الماجستير في هندسة المياه والبيئة بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.
2006

التربة والمياه الجوفية

إعداد

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الملخص

تعتبر فلسطين ذات وضع خاص بسبب الاحتلال الإسرائيلي, حيث وضع المدن في مناطق عسكرية مغلقة وإغلاق الطرق الرئيسية في فلسطين يقود إلى تعقيد مشكلة إدارة المخلفات الصلبة, وبالتالي أدت إلى خلق مكبات بديلة غير مؤهلة, والتي بدورها تساهم في تلويث المياه الجوفية.

حيث التحديد لخطورة تلوث المياة الجوفية يعتمد على التداخل بين حساسية الحوض المائي للتلوث مع مقدار التلوث الواقع على سطحه نتيجة أنشطة الإنسان.

خريطة قابلية التلوث للمياه الجوفية للضفة الغربية توضح أن أغلب المدن وخاصة مدينة نابلس قابليتها للتلوث عالية.

النتائج المتوقعة من الوضع الحالي:

– ضآلة وشح المياة في فلسطين في الحاضر والمستقبل.

– الإدارة السيئة للمخلفات الصلبة المنزلية تؤدي إلى تلوث التربة و المياة الجوفية.

– التأثير القريب أو البعيد المدى للمخلفات الصلبة المنزلية على التربة والمياه الجوفية في فلسطين غير محسوبة مع العلم أننا بحاجة لتوضيح و شرح هذه الآثار والمأثرات.

الأبحاث والإحصائيات في فلسطين تؤكد أن أسباب ونتائج سوء إدارة المخلفات الصلبة بكافة متغيراتها وعواملها لم يتم دراستها حتى هذا الزمن, ولذلك فان هذا البحث يهدف إلى:

– حساب التغير في تراكيز عصارة المخلفات الصلبة مع الزمان والمكان.

– حساب تأثير عصارة المخلفات الصلبة على التربة وعلى المياة الجوفية.

هذه الأهداف تتحقق بوضع تجربة عملية مماثلة لوضع مكبات النفايات في الحقيقة, والذي يتألف من جزئين:

- **الجزء الأول:** وهو أعمدة لاستخلاص عصارة المخلفات الصلبة, والتي تتألف من أربعة أعمدة بلاستيكية بارتفاعات مختلفة و التي هي (0.5, 1, 1.5, 2) م, حيث أقطارها 6 انش, تم وضع المخلفات الصلبة المنزلية فيها بتلك الارتفاعات.

اختلاف تراكيز العصارة يعتمد على: مكونات المخلفات الصلبة, ارتفاعاتها, وعمرها. تم حساب كمية الأمطار التي سوف تدخل كل عمود من الأعمدة بواسطة معادلة رياضية والتي قدرتها 11 لتر, تم توزيع هذه الكمية على الأعمدة في فترة زمنية تقدر بستين يوم. وتم تجميع العصارة الخارجة من أعمدة المخلفات الصلبة و تحليلها.

- **الجزء الثاني:** وهي عبارة عن أعمدة لصب عصارة المخلفات الصلبة على أعمدة التربة (تربة مكب النفايات), و التي تتألف من ستة أعمدة بلاستيكية بارتفاع 2م وقطرها 6 انش, تم وضع عصارة المخلفات الصلبة الناتجة من كل عمود من القسم الأول للتجربة في عمود من التربة, حيث أربع أعمدة من المخلفات الصلبة المنزلية (من القسم الأول من التجربة) يتبعها أربعة أعمدة من التربة. وتم وضع عمود من التربة يصب فيه ماء نقي أي لم يمر في مخلفات صلبة. وعمود تربة يصب فيه العصارة الخارجة من عمود تربة أخر, أي بمعنى آخر عمود من المخلفات الصلبة يصب عصارتة في عمود من التربة بارتفاع 4م. وتم في هذا الجزء من التجربة تحليل عصارة المخلفات الصلبة الخارجة من عمود من التربة, وتحليل تربة جميع الأعمدة.

التحاليل المخبرية:

1- **تحاليل العصارة:** تم تحليل عينات العصارة الخارج من كافة أعمدة المخلفات الصلبة المنزلية, وتحليل عينات العصارة الخارجة من إحدى أعمدة التربة.

وهذه الفحوصات التي تعبر عن خصائص عصارة المخلفات الصلبة المنزلية وهي:

pH, EC, TSS, TDS, BOD_5, Ca, Mg, Na, K, Cl CO_3, HCO_3, alkalinity, hardness, Sulfate, Phosphate, Iron and Nitrate.

2- تحاليل التربة: تم تحليل عينات التربة من كافة أعمدة التربة بارتفاعات مختلفة.

هذه الفحوصات تنقسم إلى قسمين:

1- فحوصات فيزيائي: والتي هي فحص الحموضة, وتركيز المواد الصلبة الذائبة, والتوصيل الكهربائي للتربة, ونوع التربة التابع لأقطار ذراتها.

2- فحوصات كيميائية: والتي تنقسم إلى قسمين و هم:

مصادر الأملاح وهي: الصوديوم, والمغنيسيوم, والكلور, والكالسيوم.

المصادر المغذية للتربة: وهي البوتاسيوم, والنيترات, والفسفور.

نتائج هذه الدراسة:

- المواد الصلبة المعلقة والذائبة في عصارة المخلفات الصلبة المنزلية تزيد بزيادة عمق المخلفات الصلبة, و تقل بزيادة كميات الماء المضافة.

- التربة صالحة للزراعة

- إمكانية معالجة عصارة المخلفات الصلبة بتمريرها في التربة.

- وضع معادلات تربط بين تراكيز عصارة المخلفات الصلبة باختلاف ارتفاع المخلفات الصلبة, مع الزمن.