An-Najah National University

Faculty of Graduate Studies

Fate of Amoxicillin, Ibuprofen, and Caffeine in Soil and Ground Water Using Soil Columns

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This Thesis was defended successfully on 8/5/2012 and approved by:

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Dedication

To the most generous to all of us, the martyrs.

To the wounded, prisoners and detainees.

To give of himself in support of Palestine.

To my parents who always encouraged me to science and progress and

knowledge.

To everyone who helped and supported me in my research with Love and

Respect.

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Thanks and appreciation goes out to various people whose direct and indirect support has helped me to produce this thesis.

الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان :

Fate of Amoxicillin, Ibuprofen, and Caffeine in Soil and Ground Water Using Soil Columns

أقر بأن ما اشتملت عليه هذه الرسالة إنما هي نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وأن هذه الرسالة ككل، أو أي جزء منها لم يقدم لنيل أية درجة أو لقب علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى .

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name :   اسم الطالب :

Signature :   التوقيع:

Date: التاريخ:

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Abstract

The recent public interest regarding the presence of pharmaceutical pollutants in water has raised important concerns due to the unknown environmental impact especially on aquatic life, soil and underground water as emerging aquatic micro pollutants that have possibly been affecting the ecological system and lead research studies in recent years.

In this study three pharmaceuticals were selected, ibuprofen, amoxicillin and caffeine as examples of pharmaceuticals that are released into the environment, all are marketed in the Palestinian market (pharmacies), private clinics, hospitals either for human veterinary use.

 In this research we have investigated the adsorption behavior of three pharmaceuticals on soil, the effect of temperature and pH on the adsorption process, in addition their effect on characteristics of underground water, all were studied using the UV-V is spectrophotometry.

The results of experimental sorption data fitted very well the Freundlich isotherm model and first order kinetics model.

During the study of soil columns the study revealed that the concentration of caffeine in leachate higher than those of ibuprofen and amoxicillin, because caffeine has higher solubility in water, despite it didn't reach 1ppm. While ibuprofen and amoxicillin were present in leachate with very small concentrations due to their degradation and decomposition into other substances that may be harmful, and would affect the natural properties of soil, groundwater and human health. Therefore, we recommend further studies of these drugs and find out how dangerous to human health.

Chapter One

1.1. General Introduction

In the recent years, the occurrence and the fate of pharmaceutically active compounds in the aquatic environment has been recognized as one of the emerging environmental issues that have possibly been affecting the ecological system, **(Dietrich,D, D.R., et al.,2005); (Kotchen, M., 2009**). Pharmaceutical compounds may be described as any chemical used for diagnosis, treatment, alteration or prevention of diseases, **(Thompson, A., 2005)**. Taking into account the use of thousands of pharmaceuticals types in human treatment and in agricultural sector (livestock), it's not limited the size on the negative effects that these compounds will leave on the environment, as well as high cost to eliminate or mitigate these effects.

It was discovered about more than 100,000 types of chemicals that are used in our everyday life either in households, industries or agriculture, **(Kummerer, K., 2004)**. So pharmaceutical pollution is one of the most modern and chemical contaminants that pose to the environment.

The pharmaceutical compounds used mainly by human and livestock are excreted only slightly transformed or even unchanged form which result from the bodies fluids (urine), or from disposing of the expired drugs, causing serious damage to the ecosystem, which is still in the beginning of the study in Palestine, that's because our conventional

wastewater treatment is the primary mechanism by which pharmaceuticals introduced, **(Karnjanapiboonwong, K., et al, 2001).**

According to a lot of recent researches variety of these compounds were detected in various water samples including hospitals wastewater, pharmaceutical industries, waste water treatment plant effluent, surface and ground water, this illustrated by a study entitled, (occurrence of pharmaceuticals and personal care products along the West Prong little Pigeon River in east Tennessee), by (Chane P.Yu and Kung H.Chu, in USA 2009), which pointed out the presence of concentrations of some drugs in ground water and soil. In addition to the quantities of expired medicines which are disposed of in unsafe ways, it's common to pour them down in the sink, flush them down in the toilet, or throwing them in the trash,without attention to their risks through landfills leahates that may eventually reach to ground water.

Despite of the need for the drugs used for treatment of many diseases , it was found that they leave an adverse effects on non-target site , such as water, soil, air, health and others, therefore, they should be used and dealt in a scientific way to reduce as much as possible of their negative effects, by preventing drugs using randomly from general public, reducing distribution of physician free samples, separation of domestic waste, sewage recycling, improvement sewage infrastructure, public awareness, nutrition and health maintenance, drugs alternatives and research development.

Locally amoxicillin, ibuprofen, and caffeine are used in pharmaceutical manufacturing products for human and veterinary sector, whether used through physician prescription or by the person himself, this is clear from my reviews of many pharmacies and Palestinian ministry of health.

This study will investigate the fate of amoxicillin, ibuprofen, and caffeine on the soil and ground water, the adsorption behavior of the three pharmaceuticals on soil, effect of pH and temperature on the adsorption process, and equilibrium isotherm.

1.2. Objectives:

The study aims to achieve a set of goals and most important of which are the following:

1. To highlight the seriousness of the excessive use of drugs covered by the study.

2. To determine the adsorption of target ibuprofen, amoxicillin, and caffeine to soil.

3. To investigate the fate of ibuprofen, caffeine and amoxicillin on soil and ground water.

4. Create an alternative needs to minimize exposure to humane or to improve treatment process to protect human and environment.

1.3. Justification:

The presence of a lot of factories that manufacture these drugs and others, in addition to a lot of governmental and specialized hospitals in Palestine. Although pharmaceuticals and personal care products (PPCPs) may exist in minute quantities, long-term release of them may result in significant environmental concentrations and consider being one of the most dangerous contaminant for environment.

PPCPs enter the Palestinian land, via the hospitals and drugs manufacture factories, and disposal of residential wastewater which is the main source (85%) of influent to the plant. Since target PPCPs: amoxicillin, ibuprofen and caffeine may be found in septic tanks and consequently ground water due to incomplete human metabolism and excretion into the waste stream or by disposal of unused medication in the toilet or down to sink, and not be completely removed during the wastewater treatment process, these compounds may be discharged into streams and land application sites, and eventually contaminate aquatic environment or persist in surface water, groundwater, and soil.

Chapter Tow
Literature Review

2.1. Introduction

Every year large quantities of pharmaceuticals products are sold and consumed in Palestine and worldwide for diagnoses, treatment, alteration or prevention of human diseases.

According to Palestinian ministry of health statistics , the rate of imported raw materials for local drug manufacturing was(17775) kg amoxicillin, (27780) kg ibuprofen, while imported rate of caffeine in 2007 was (425)kg, after that period it has not been imported for manufacturing or using in Palestine, **(Ministry of Health, 2010).** In addition to add about 10-15% on the purchased raw quantities as manufactured medicine that donated from foreign donors.

The uses of these quantities leave a lot of adverse effects on the environment causing the so- called pharmaceutical pollution. This chapter will illustrate what has been written on the subject of previous study and research .Three pharmaceuticals were selected for study, these are amoxicillin , ibuprofen, and caffeine due to their large use, based on measured and predicted environmental concentration, risk to environment, potential to bioaccumulation and known removal in treatment processes.

2.2. Amoxicillin

2.2.1. Definition and Uses

Formulations of AMOXIL contain amoxicillin, a semi synthetic antibiotic, an analog of ampicillin, with a broad spectrum of bactericidal activity against many gram-positive and gram-negative microorganisms, (**Dimitrakopoulou, D. ,et al ., 2012.,**) (**Ball, P., 2007**). Amoxicillin chemically is D- a-amino-p-hydroxybenzyl penicillin trihydrate.
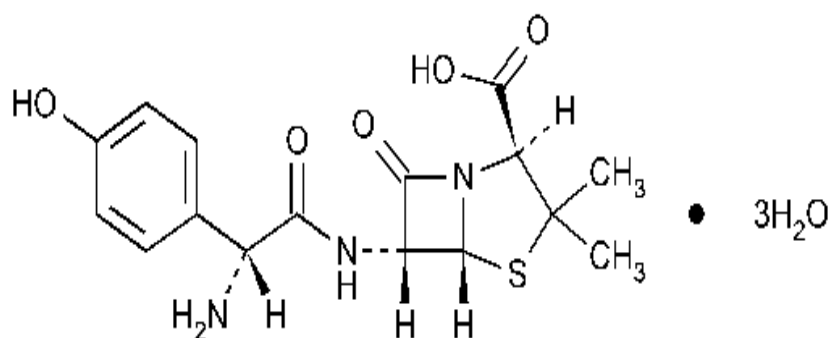
Figure 2.1: The chemical structure of amoxicillin (**Gozlan I., et al., 2010**).

It is usually the drug of choice within the class because it is better absorbed, following oral administration, than other beta-lactam antibiotics, (**Bruhn, S. T. 2003**).

Amoxicillin is susceptible to degradation by β-lactamase-producing bacteria, and so may be given with clavulanic acid to increase its susceptibility.

Penicillin, which was first, discovered by Sir Alexander Fleming in 1928 when he noticed it being produced by the mould *Penicillium notatum.*

However, amoxicillin is an artificially altered (semi synthetic) variant of penicillin, and was first made in 1972, **(Geddes, A.M, et al 2007).**

2.2.2. Mode of Action

Amoxicillin is a bactericidal antibiotic (kill the bacteria). It prevents bacterial cell wall mucopeptide synthesis by acylating the enzyme transpeptidase, thus making it unable to cross-link muramic acid containing peptidoglycan strands. This inhibition of the biosynthesis of dipeptidoglycan, a substance necessary for cell wall strength and rigidity, results in a defective cell wall.

2.2.3. Pharmacokinetics

Amoxicillin is rapidly absorbed by the gastrointestinal tract after oral administration and is stable in the presence of gastric acid. Peak serum concentrations are usually attained within 1- 2 hours following oral administration. Amoxicillin diffuses readily into most body tissue and fluids, with the exception of the cerebrospinal fluid, although higher concentrations of the drug may be attained in patients with inflamed meningitis. Its elimination half-life ranges from 0.7 to 1.4 hours in patients with normal renal function. Amoxicillin is partially metabolized to microbiologically inactive metabolites and both are then rapidly excreted in urine, small amounts of the compounds are excreted in feces and bile. **(Ball, P., 2007), (Paintaud, G., et al., 1992).**

2.2.4. Medical uses

Amoxicillin is used to treat certain infections caused by bacteria, such as pneumonia, bronchitis, gonorrhea, and infections of the ears, nose, throat, urinary tract, and skin. It is also used in combination with other medications to eliminate *H. pylori* bacteria that cause ulcers. Amoxicillin is in a class of medications called penicillin-like antibiotics, and it works by stopping the growth of bacteria, **(Ball, P., 2007).**

2.2.5. Veterinary Use

The amoxicillin/clavulanic acid combination has trade names include Clavaseptin, Clavamox and Synulox. that used in veterinary medicine for treatment of urinary tract, skin, enteritis, respiratory tract infections, soft tissue infections, metritis and mastitis. Amoxicillin/clavulanic acid is banned from use in domestic-food animal (cattle, swine, etc.) in both the US and Europe, **(Georgios, A.D., 2010).**

2.2. 6. Adverse Effects

Side-effects of amoxicillin include nausea, vomiting, rashes, and antibiotic-associated colitis, diarrhea also may occur. Rarer, but patient-reported, side-effects include mental changes, lightheadedness, insomnia, confusion, and anxiety, sensitivity to lights and sounds, and unclear thinking. Use of the amoxicillin/clavulanic acid combination for more than one week has caused mild hepatitis in some patients. Young children

having ingested acute overdoses of amoxicillin manifested lethargy, vomiting and renal dysfunction, (**Denes, A., et al., 2009**).

2.3. Ibuprofen

2.3.1. Definition

Ibuprofen is one of the most prescribed and consumable global non-steroidal anti-inflammatory drugs (NSAIDs), with analgesic and antipyretic properties, which is a prop ionic acid derivative, (**Jacobs, L.E., et al., 2011**). Ibuprofen is one of the most consumed medications corresponds to the classification of the non-Steroidal anti-inflammatory drugs (NSAIDs), and more than 70 million annual prescriptions in the world, (**Me´ndez-Arriaga, F., et al., 2010**).

Ibuprofen is a core medicine in the world health 0rganization, have an anti- platelet effect, though it is relatively mild and short-lived when compared with aspirin or other better-known anti platelet drugs. Originally marketed as Brufen, and is available under a variety of popular trademarks, including Motrin, Nurofen, Advil, and Nuprin. Its half life is 1.9-2.2 hours, with molecular weight is 206.281 g/mol, (**Jarrr, A.A., 2003**), (**Zheng, J.P., 2007**) and have the structural formula:
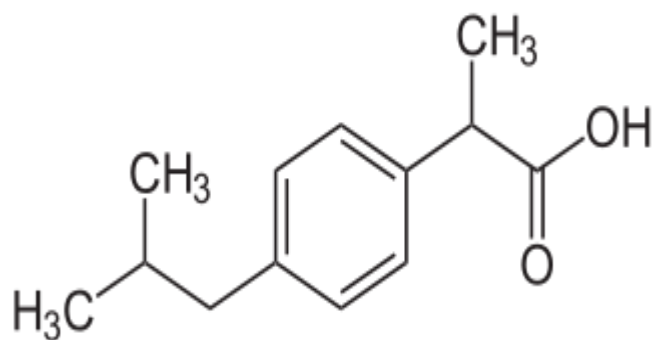
Figure 2.2: The chemical structure of Ibuprofen, **(Siskou, I.C., et al., 2007).**

2.3.2. History of Ibuprofen

Ibuprofen was discovered as a form of propionic acid in 1961, how its name came is unknown. It was made and discovered at the Boots Company in the 1960s in the United Kingdom. It was discovered by Andrew RM Dunlop, with colleagues Stewart Adams, John Nicholson, Vonleigh Simmons, Jeff Wilson and Colin Burrows, and was patented in 1961. Ibuprofen was made available under prescription in 1969, and in the United States in 1974, **(Rang, H.P, et al, 1995).**

2.3.3. Mode of Action

The exact mechanisms of action of Ibuprofen is unknown, its anti inflammatory effects are believed to be due to inhibition of both cylooxygenase-1 (COX-1) and cylooxygenase-2 (COX-2) enzymes which leads to the inhibition of prostaglandin synthesis, and this is the cause for the analgesic and anti-inflammatory action of the drug. **(Rang, H.P, et al, 1995).**

2.3.4. Pharmacokinetics:

Ibuprofen is well absorbed from the gastrointestinal tract. It is highly bound (90-99%) to plasma proteins and is extensively metabolized to inactive compounds in the liver, mainly by glucuronidation. Both the inactive metabolites and a small amount of unchanged ibuprofen are excreted rapidly and completely by the kidney, with 95% of the administered dose eliminated in the urine within four hours of ingestion, **(Rang, H.P, et al, 1995)**.

2.3.5. Medical Uses of Ibuprofen:

Ibuprofen is a non steroidal anti-inflammatory drug (NSAID), used in both human and veterinary medicine for treatment of a wide range of conditions. It is used to treat headaches, muscle aches, backaches, dental pain, menstrual cramps, arthritis, or athletic injuries. It is also used to reduce fever and to relieve minor aches and pain due to the common cold or flu, by the enzyme in the body that makes prostaglandins, and decreasing prostaglandins helps to reduce pain, swelling, and fever, **(Jarrr, A.A., 2003).**

2.3.6. Ibuprofen Interactions

Ibuprofen can interact with an anticoagulants, including warfarin-ibuprofen may increase risk of severe bleeding and sometimes fatal hemorrhage, especially from the gastrointestinal tract. Ibuprofen should

only be used in patients taking warfarin if absolutely necessary and they must be closely monitored. It may reduce the anti-hypertensive effect of beta-blockers and diuretics and may cause hyperkalemia in patients under these treatments.

Ibuprofen may prolong bleeding time in patients treated with zidovudine, and may also interact with probenecid, antidiabetic medicines and phenytoin, **(Hersh, E.V., et al., 2007)**

2.3.7. Side Effects of Ibuprofen:

Adverse effects with non-prescription or short-term use ibuprofen are rare and may include:

- gastrointestinal–dyspepsia, heartburn, nausea, loss of appetite, stomach pain, and diarrhea.
- Central nervous system (CNS)–dizziness, fatigue, headache, and nervousness.
- Hypersensitivity reactions-skin rashes and itching. Rarely dermatitis and epidermal necrolysis have been reported with ibuprofen.
- Rare cases of photosensitivity.
- Cardiovascular-fluid retention and in some cases oedema, these effects are rare at non-prescription doses.
- Allergic reactions such as skin rash, itching, swelling of the face or breathing difficulties may also occur, **(Al-Nasser, A., 2000)**.

2.4. Caffeine

2.4.1. Definition and Use

Caffeine is white crystalline xanthine alkaloid, very common substance that acts as a central nervous system stimulant drug , which is found in leaves, seeds and/or fruits of at least 63 plant species worldwide, and is part of a group of compounds known asmethylxanthines, have molecular weight 194.19g/mole and structural Formula: $C_8H_{10}N_4O_2$ as shown:
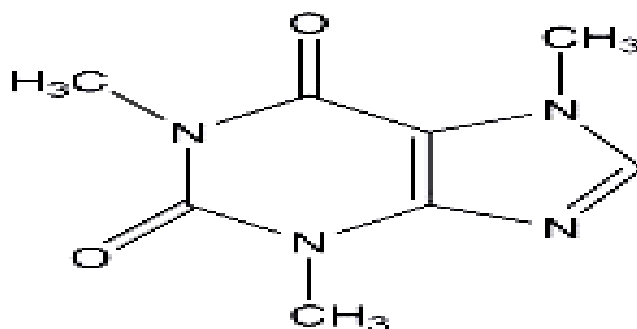
Figure (2.3): The structural formula of caffeine

The most commonly known sources of caffeine are coffee, cocoa beans, tea, chocolate, soft drinks, and can also be purchased as capsules, tablets, or powder, (Jacobs,L.E., et al., 2012). Other sources of caffeine include over-the-counter pain relievers and cold medications.

Caffeine is an adjuvant to increase the rate at which the medication is absorbed into the body; it can be present in these products ranging from 16-200 mg.

2.4.2. History of Caffeine

Caffeine is one of the world's most widely used drugs that were first extracted from coffee in 1821. Coffee originated in Ethiopia and later introduced to Arabia and the rest of the east. Ethiopian nomads discovered coffee through their animals, the animals would eat the fruits from the trees they would have an energy boost; the nomads tried eating the seeds and had an increase in energy. In 1573 coffee was introduced to the Europeans, tea was introduced later in 1657 and became very popular to the people of Europe. Near the end of the 19th century cola products started to appear around the world and became one of the larger drank caffeine drinks, **(Smith, A., (2002).**

Caffeine was first isolated from coffee in 1820 by the German chemist Friedlieb Ferdinand Runge, and then independently by French chemists Pierre Robiquet, Pierre Pelletier, and Joseph Caventou, **(Waston, J., 2003).**

2.4.3. Pharmacokinetics of Caffeine

Caffeine is administered orally and intravenously, and is well absorbed from the gastrointestinal tract, following oral administration, peak plasma concentrations in adults are reached within 50-75 minutes. Therapeutic caffeine concentrations are reported to be 5-25 mg/L in adults.

Caffeine is distributed rapidly to all body tissues and readily crosses the blood-brain and placental barriers and is distributed into breast milk, it is roughly 36% bound to plasma proteins.

In adults, caffeine is partially metabolized in the liver via demethylation reactions, dependent on the Cytochrome P450 isoenzymes; major metabolites include paraxanthine (80%), theobromine (10%), and theophylline (4%). The plasma half-life of caffeine is 3-7 hours in adults.

Caffeine metabolism in neonates is limited due to their immature hepatic enzyme systems, therefore unchanged caffeine and its metabolites are excreted in the urine. Plasma half-life for neonates may vary widely, from 65-100 hours, and the fraction of caffeine excreted unchanged in the urine is roughly 86% within 6 days. Young infants have a plasma half-life of caffeine of 3-4 days, **(Abel, P; Joju George, A.D., 2008).**

2.4.4. Mechanism of Action of Caffeine

Caffeine is a mild, direct stimulant at all levels of the CNS and also stimulates the heart and cardiovascular system. The related xanthine, theophylline, shares these properties and is widely used in the treatment of pulmonary disease. Caffeine also stimulates the medullar respiratory center and relaxes bronchial smooth muscle, also it stimulates voluntary muscle and gastric acid secretion, increases renal blood flow, and it have a mild diuretic effect, **(Rang H.P., et al., 1995).**

2.4.5. Medical Use of Caffeine:

Caffeine is used as a central nervous system (CNS) stimulant, anorexiant, diuretic, and in a number of analgesic and cold medication compounds. It is also used in the treatment of spinal headaches and has been used as a respiratory stimulant in preterm infants.

Some people use caffeine for asthma, gallbladder disease, attention deficit-hyperactivity disorder (ADHD), shortness of breath in newborns, and low blood pressure. It is also used for weight loss and for type two diabetes, and is one of the most commonly used stimulants among athletes. Caffeine creams are applied to the skin to reduce redness and itching in dermatitis.

Healthcare providers sometimes give caffeine intravenously (by IV) for headache after epidural anesthesia, breathing problems in newborns, and to increase urine flow.

In foods, caffeine is used as an ingredient in soft drinks, energy drinks, and other beverages. People with voice disorders, singers, and other voice professionals are often advised against using caffeine, **(Waston, 2003).**

2.4.6. Caffeine Side Effect

Whether caffeine is consumed in food or as a medicine, it changes the way your brain and body work and changes how you behave and feel, it is a central nervous system stimulant, **(Smith A., 2002)**. Caffeine's main

effect on body is make feel more awake and alert for a while, but it can also cause problems according to several studies, most important of them the study that conducted by the Organization of Teratology Information Specialists that caffeine can make shaky, hard to fall asleep, increase heart beat speed, cause an uneven heart rhythm, raise blood pressure cause headaches, nervousness, and/or dizziness, addiction, (make you dependent on it so you need to take more of it), **(Organization of Teratology Information Specialists, 2011)**; **(Waston J., 2003).**

2.5. Amoxicillin, Ibuprofen and Caffeine in Environment

Each year large quantities of these drugs are sold and consumed in the worldwide and USA for diagnosis, treatment, and prevention of human diseases, the reasons are that these amount keep increasing because of improving health care system and long life expectations of people, **(Xia, K., et al.,2005).,(Skadsen J.M., et al .,2004)**.

People all over the world consume millions of doses of medication through physician prescription and over-the-counter, as well as millions of other veterinary either orally or by injection. As mentioned earlier, and according to the statistics of Palestinian ministry of health, tons of raw materials are consumed every year, the average of their consumption in both humanitarian and veterinary sector in the year of   2010 reached 17,775 kg of amoxicillin, 27780 kg of ibuprofen, and 425 kg of caffeine just for the 2007, for local manufacturing, adding 10-15 % on the

purchased raw materials as a donated medicine from foreign donors, **(Palestinian Ministry Of Health, 2010)**. In addition to the quantities of expired medicines which are disposed of in unsafe ways, it's common to pour them down in the sink or flush them down in the toilet, also manufacturing waste, waste from human or animal excretion. Once the pharmaceuticals in the environment, it may metabolite from the parent compound and distributed between major environment compartments, the concentration in these compartment depend on numerous factors, including how the parent compounds is released in the environment, how fast it degrades, the half life of metabolite, soil and sediment and subsequent movement to air and water, **(University of Aveiro, 2008)**.

Environmental monitoring has identified a number of pharmaceuticals including ibuprofen, mood stabilizers (caffeine), antibiotics, present in some environments at level high to harm aquatic organism. **(Chane, P.Yu, 2009)**. Through a review of several references is clear that the drugs found in the environment, where it was clear in a study conducted in the United States in 1999-2000 by a geological survey, that the most water ways contain at least some antibiotics synthetic hormones, steroids, or other common drugs. The survey sampled 139 streams in 30state, found that about 80% contained antibiotics, analgesics, steroids, caffeine, hormones, and other contaminants, half of the stream contained seven or more chemical compounds, one-third of streams contained 10 or more

compounds and one sample contained 38 chemical,**(Morse, A., Jackson, A., 2003)** .

2.6. Source of Pharmaceutical in Environment

In spite of all benefits of these drugs in the treatment of many diseases for human and animals, but the added to the environment in large quantities, through several sources that include:

- Direct disposal at manufacturing.

- Excretion with urine and feces (sewage water).

- Drugs in animal manure.

The amount of pharmaceutical that can be discharged by the producer to the sewage can be 1-5% of total production, this is low compared to other type of industry, this type of industry produce several kinds of chemicals from drugs, catalyst, solvent and other per unit of actual product that goes to municipal sewage treatment plants (STPs). Industrial waste water may be possible source for contamination of surface water. The following picture shows the routes of the pharmaceuticals entering to the environment:
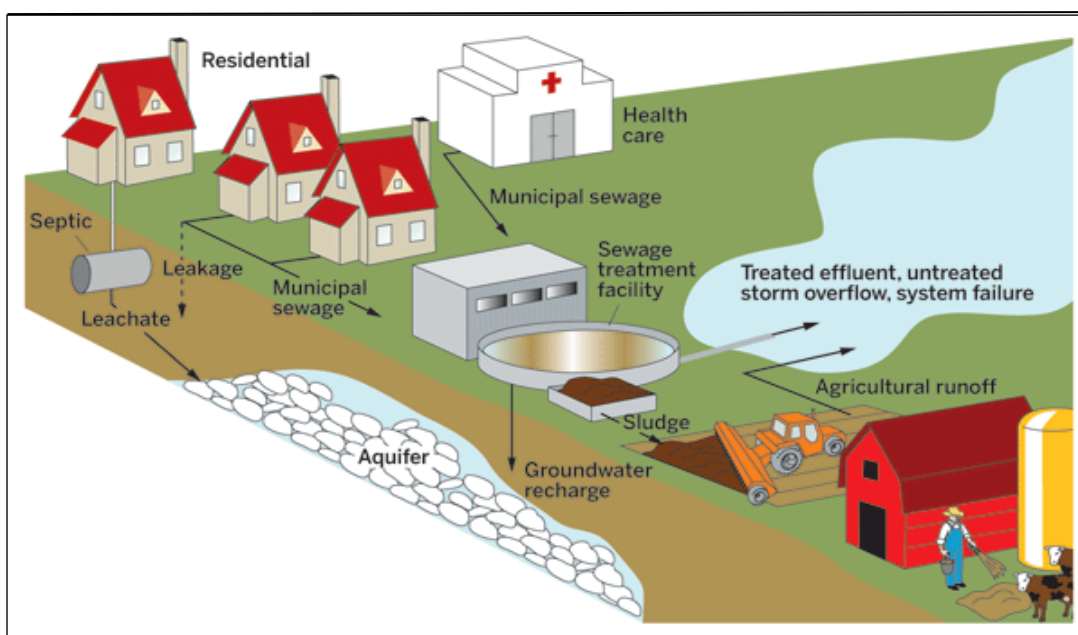
Figure (2.4): Drug flow Pharmaceuticals and their metabolites enter environment from homes, health care facilities, and farms, **(Bethany Halford, 2008).**

The pharmaceutical administrated (in its medical term or other words consumed) by human after required action in the body get excreted with urine and feces as (original compound), and usually as a number of metabolites. The important issue about the pollution that occurs with medication that result from household disposal of unused or expired medications is that some of these products can cause environmental damage if disposed into the sewer system ,because these materials are not adequately destroyed by sewer treatment plants, **(Dietrich D.R., et al ., 2005)**, toilet wastewater is mixed with other wastewater stream forming finally a sewage that enter the municipal sewer, human pharmaceuticals have to pass through "STPs "prior to entering rivers or streams. In sewage treatment plants (STP) effluents many pharmaceutical compounds do not get removed to a sufficient degree, this because (STP) are not efficient enough to remove these micro pollutants, consequently they enter the

surface water where they may pose effect onto aquatic life, **(Katarzyna, K-R., et al., 2007)**

In animal husbandry, pharmaceuticals are used worldwide not only for therapeutic purpose but also for animals growth promotion, large proportion of antibiotics is excreted through manure, some of manure used as fertilizer, the remaining antibiotics or other pharmaceuticals and their metabolites enter soil, where they might persist or reach ground water, **(Binh C.T. Th, et al., 2007).** The resulting pharmaceuticals residues especially antibiotics can affect the natural soil microbial community and soil function and may even harm animals and human via the food chain,**(Institute of soil science, 2003, and Environmental Toxicology and Pharmacology , 2008).**

Once PPCPs are released to the environment, their behavior will be determined by their physical and chemical properties such as water solubility, lipophilicity, vapor pressure, and sorption coefficients. These properties may help determine whether they are likely to partition between water, air, or soil environments. Photolysis, biodegradation, and sorption of PPCPs can contribute to their elimination and mobility in the environment, **(Todd, A. A., 2010), (Xu .J, et al 2009).**

One of the aims of this study was to determine the presence of all concentrations of amoxicillin and ibuprofen and caffeine in the soil, from

here should be identified on soil properties and mechanical process of absorption and adsorption of these drugs on soil.

2.7. Definition of Soil

Soil is the unconsolidated mineral or organic material on the immediate surface of the earth and serves as a natural medium for the growth of land plants. The soil is composed of particles of broken rocks that have been changed by environmental and chemical processes that include weathering and erosion. It's a mixture of minerals and organics components that are in gaseous, solid, and aqueous state. Most soils have a density between 1-2 gram\cm^3. Soil particles are loosely packed, forming a soil structure that filled with pore and spaces, these pores contain air (gas) and solution (liquid), as shown in following figure:
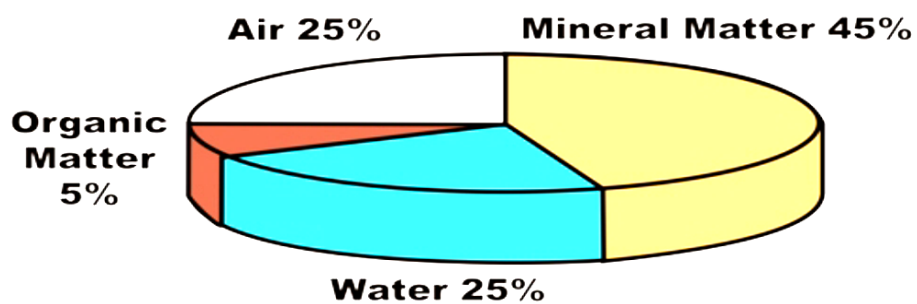
Figure 2.5: Soil structure, (**Daniel H, (1998)**

Most soil consists of combination of three types:

- Sandy soil : particles size 0.5-2 mm, texture is gritty, compaction is low), porous, and usually holds less water for plants than other soil types, and it have the property of dryness, its particles tend to be weakly bonded together , so sandy soil easily affected by erosion .
- Silt soil: particles size 0.02-0.5 mm, texture is smooth and slippery, compaction is medium, have small particles and weaker than those formed by clay particles.
- Clay: a particle size less than 0.02 mm, texture is sticky, compaction is high, and have small particles that tend to bonded together strongly, can tend to hold water.

The important physical properties of soil is the pH, which controlled by the concentration of hydrogen ion in the soil. The availability of hydrogen ions in soil matrix is caused by chemical weathering reaction and by dissociation of water by action of roots.

Soil with large concentration of hydrogen ion tend to be acidic, and many of nutrients become soluble and readily leached from the soil to the ground water, but soil with low concentration of hydrogen ions tend to be alkaline so nutrients become insoluble and plant cannot extract them.

The chemicals movement(transport) processes through soil are diffusion, convection, and hydrodynamic dispersion,   and chemical

properties of soil like solubility, sorption, and density influence the ability of substances to be transported within soil.

More soluble chemical tend to move more easily within water than that are less soluble water, which will tend to attach to clay particles and organic matter near the soil surface, (**Naser.O.Z. M, 2011).**

2.8. Chemical Kinetics

2.8.1 Rate of Reaction

The rate is defined as change in concentration (Δc) with time **(Δt)**. The rate can be positive or negative: a positive rate means that the concentration is increasing with time e.g. a product; a negative rate means that the concentration is falling with time e.g. a reactant. A rate law is a mathematical equation that describes the progress of the reaction. In general, rate laws must be determined experimentally. There are two forms of a rate law for chemical kinetics:

• Differential rate law.

• Integrated rate law.

The differential rate law describes how the rate of reaction varies with the concentrations of various species, usually reactants, in the system.

Each rate law contains a constant" k" called the rate constant. The units for the rate constant depend upon the rate law, and the concentration always has units of mole\L.

The rate is the derivative of concentration with respect to time.

$$r = -d\,[A]\,/\,dt \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (2.1).$$

Integrated rate law relates the concentration to time.

$$r = k\,[A]^n \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (2.2).$$

2.8.2 Order of Reaction

The power to which its concentration term in the rate equation is raised. For example, given a chemical reaction $2A + B \rightarrow C$ with a rate equation.

$$r = k\,[A]^2[B] \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (2.3).$$

The reaction order with respect to A would be 2 and with respect to B would be 1; the total reaction order would be $2 + 1 = 3$.

2.8.2.1 Zero-Order Reaction

The rate of reaction is a constant when the limiting reactant is completely consumed.

Differential Rate Law:

r = k…………………………………………………………………........ (2.4).

The rate constant, k, has units of mole/ L / sec.

2.8.2.2 First-Order Reaction

For a first-order reaction, the rate of reaction is directly proportional to the concentration of one of the reactants.

Differential Rate Law:

r = k [A] ……………………………………..…………………….............. (2.5)

− [dt] / [A] = k*A……………………………………………………….. (2.6)

$[A] = [A] \, 0 \, e - ^{k \, t}$ ……………………………………………….......... (2.7)

$[A] / [A] \, 0 = 1/2 = e -kt^{1/2}$ …..…………………………………… (2.8)

Taking the ln of both sides

ln (1/2) = - ln 2 = - k t $_{1/2}$…..………….…………………………........... (2.9)

Or t 1/ 2 = (ln 2) / k……………….…………………………..……….. (2.10)

For any order other than first order, the half-life of the reaction is dependent on the concentration. The rate constant "k" has units of sec-1.

2.8.2.3 Second-Order Reaction

For a second-order reaction, the rate of reaction is directly proportional to the square of the concentration of one of the reactants.

Differential Rate Law:

$$r = k\,[A]^2 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2.11).$$

$$-d\,[A]\,/\,dt = k*[A]^2 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2.12).$$

$$[A]\,/\,1 + kt\,[A]^0 = [A] \dots\dots\dots\dots\dots\dots\dots\dots\dots (2.13).$$

$$t1/\,2 = 1/\,k\,[A]^0 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2.14).$$

The rate constant, k, has units of L mole^{-1} sec^{-1}.

| Zero-order | first-order | second-order |
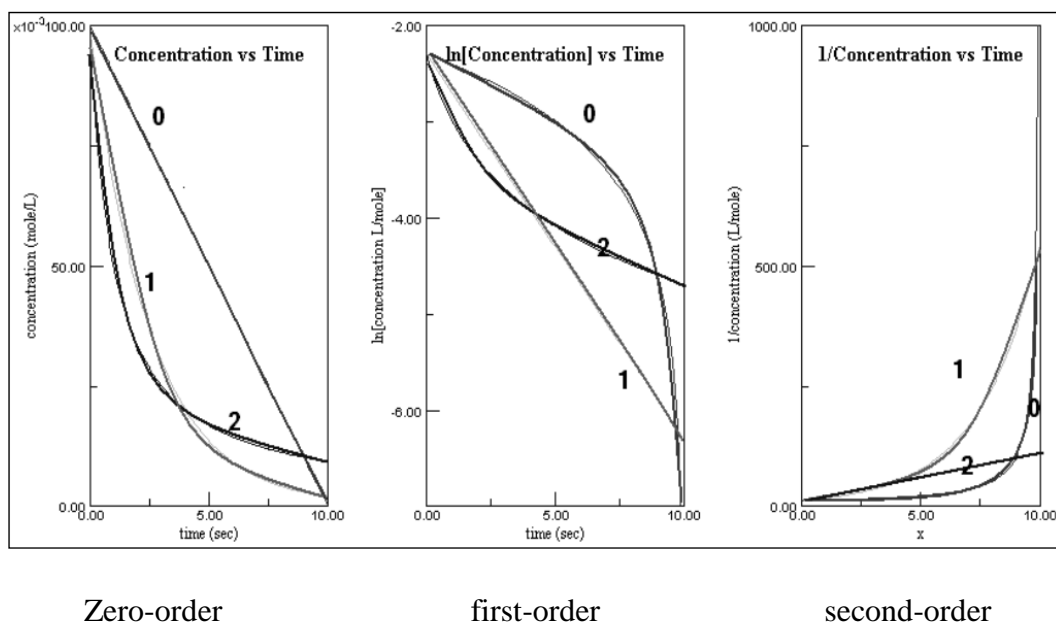
Figure. 2.6: The use of the characteristic kinetic plots **(Attaallah, M.A., 2011).**

2.9. Adsorption onto Soil

Adsorption phenomenon in solution systems plays an important role in many areas of practical environmental technology. In water and wastewater treatment, for example, the adsorption technique has found wide applicability because of several advantages such as high efficiency, simple operation, and easy recovery/reuse of adsorbent.

It is of general interest to understand pharmaceutical adsorption from an aqueous environment to a solid surface. The characteristics of the adsorption behavior are generally understood in terms of both equilibrium, and adsorption kinetics.

Adsorption: is the phenomenon of attraction or adhesion of solute molecules to the surface of soil particles at an interface between two phases which can be solid –liquid. The driving force for adsorption result from specific affinity of solute to the soil where the atoms at the solid surface subjected to unbalanced force of attraction , so adsorption is essentially a surface phenomenon, **(LeVan, M.D., 2008).**

Absorption: is the uniform distribution of the substance throughout the bulk, adsorption essentially happens at the surface of the substance. When both adsorption and absorption processes take place simultaneously, the process is called sorption. Most soils absorb water and chemicals, although in amount much less than those adsorbed.

Adsorption process involves two components adsorbent and a dsorbate. Adsorbent is the substance on the surface of which adsorption takes place.

A dsorbate is the substance which is being adsorbed on the surface of adsorbent. The adsorption process includes electrical attraction of the solute to adsorbant, vander-waal attraction or chemical nature, **(Aly, O.M and Faust, S.D., 1964)**.

Adsorption can be classified into two types: Physical Adsorption or Chemical Adsorption:

- Physical Adsorption or Physisorption: occur when the force of attraction existing between a dsorbate and adsorbent are weak Vanderwaal forces of attraction, Physical Adsorption takes place with formation of multilayer of a dsorbate on adsorbent. It takes place at low temperature, and its fully reversible reaction where adsorption occurs at the same temperature and the process may be slow because of diffusion effects. Molecules in the physical adsorption are free to undergo translation movement within interface.

- Chemical Adsorption or Chemisorption **:** occur when the force of attraction existing between a dsorbate and adsorbent are by chemical bond, includes the transferring of electrons, as a result there is chemical bond and chemical adsorption is irreversible it takes place with formation of unilayer of a dsorbate on adsorbent. Molecules in chemical adsorption are not

considered to be free to move on the surface where they attached to active center. Chemical interaction between adsorbent and a dsorbate is favored by high temperature**, (Ruthven, M.D., (2004).**

2.9.1. Adsorption Equilibrium Isotherms

Adsorption equilibrium is the physic-chemical aspect which determine the adsorption capacity, as the adsorption process continue, the solute that is adsorbed tend to desorbs so equal amount of solutes are adsorbed and desorbed at the same time, where no change can be observed in the solute concentration and the system reach equilibrium. The equilibrium position is characteristic of entire system, the solute, adsorbent, solvent, temperature, pH, and so on, **(Aly, O.M., and Faust, S.D., 1964**); **(Ruthven, M.D., 2004).**

Adsorption Isotherm: is the amount of solute adsorbed per unit of adsorbent as a function of equilibrium concentration of adsorbent in the bulk under a set of experimental conditions. Adsorption isotherm can be generated based on theoretical models where Langmuir and Freundlich models are the most commonly used ones, **(Helby, W.A., 1952).**

The Langmuir isotherm, originally derived for the adsorption of gas molecules on solid surfaces, was modified to fit the adsorption isotherm of solutes onto solid surfaces in solution systems, **(Sohn, S., and Kim, D., 2005); (Pei, J., and Zhang, 2012).**

When solute molecules adsorbed on the surface of the soil, these adsorption may appear in two forms: single layer adsorption or multi molecular layer adsorption. Several type of isotherm may occur Langmuir and Freundlich isotherms are valid for single layer, where for multilayer Brunauar Emmett and Teller (BET) isotherm are valid.

The Langmuir equation is expressed as:

$$X / m \quad = \quad X_m bC_e / 1 + bC_e \qquad \text{(equation 2.15)}$$

Where:

X : amount of solute adsorbed in moles (mg, mole).

m: weight of adsorbent (mg, g).

b: a constant related to the heat of adsorption, 1/ unit weight.

Xm: amount of solute adsorbed per unit weight of adsorbent required

for monolayer.

Ce: equilibrium concentration of the solute.

For linearization of equation (2.15), it can be written in the form:

$$C_e * m / x \quad = 1/ bx_m + C_e / x_m \qquad \text{(equation 2.16)}$$

Or

$$m / x = 1/ X_m + Ce / bx_m * 1/ Ce \qquad \text{(equation 2.17)}$$

Any of these equations may be used to evaluate "b " and "Xm" from experimental data using graphic or linear least squares analysis, **(Rubin, A.J., and Mercer, D.L., 1984).**

Freundlich adsorption equation is perhaps the most widely used mathematical description of adsorption in aqueous systems.

The Freundlich equation is an empirical equation based on adsorption on a heterogeneous surface. The equation is commonly represented as:

$$\log Cs = \log K + \log Ci \qquad \text{(equation 2.18)}$$

Where:

Cs: is the concentration of pharmaceutical adsorbed on red soil

(mg/g).

Ci : is the concentration of pharmaceutical remained in solution

(mg/L).

K & n: are the Freundlich constants characteristics of the system, indicating the adsorption capacity and adsorption intensity respectively, **(Soil Science and Plant Nutrition, 2001)**; **(Aly, O.M and Faust, S.D, 1964).**

2.10. Previous Studies:

Adsorption is integral to a broad spectrum of physical, biological, and chemical processes and operations in the environmental field. Both adsorption and desorption of the different materials in the environment can be studied kinetically by using different equations like Freundlich and Langmuir isotherms and by knowing especial conditions like PH, time, temperature , concentration and other different condition .

Many researchers in the world and in Palestine studied the kinetics behavior and fate of may pharmaceuticals in the environment like:

• Adcharee Karnjanapiboonwong, et al, (2011): Occurrence of PPCs Wastewater Treatment Plant and in Soil and Groundwater at a Land Application Site, in USA.

Adcharee Karnjanapiboonwong and his team studied the presence of eight types of drugs (estrone, 17β-estradiol, estriol, 17α-ethynylestradiol, triclosan, caffeine, ibuprofen, and ciprofloxacin) in wastewater, sewage sludge, soil, and groundwater. The results indicated that concentrations of PPCPs in wastewater influent, effluent, sludge solid phase, and sludge liquid phase were in the range of non-detected (ND)-183 μg/L, concentrations in soil and groundwater samples were in the range of ND-319 ng/g in soil and ND-1,745 μg/L in ground water, respectively Overall, data indicate that PPCPs in the wastewater effluent from the waste water

treatment plant   WWTP transport both vertically and horizontally in the soil, and eventually reach groundwater following land application of the effluent, **(<u>Karnjanapiboonwong, A., et al. 2011</u>).**

• Awartani Lama, (2010): Fate of Oxytetracycline and Doxycycline in Soil and Underground Water in Palestine.

Awartani studied the adsorption behavior of two antibacterials, oxtetracycline and doxycyclin that are released into soil, also studied the effect of organic matter and magnesium chloride hepta hydrate addition on the adsorption of the two antibacterials. The results showed that increasing organic matter increases the adsorption of tetracycline more than doxycycline, also showed that the composition of oxytetracycline complex with magnesium ion was more stable than doxycycline complex with magnesium. The study also revealed a higher concentration of doxycycline in leachate water from the soil than those of oxtetracycline due to its higher solubility in water, in addition to decrease of the concentrations for both substances over time in leachate over time in leach ate water due to degradation**, (Awartani, L., 2010).**

• Hattab Areej, (2010), Palestine**:** Adsorption of some fluoroquinolones on selected adsorption.

Hattab Areej studied the adsorption of some fluoroquinolones (antibiotic) such as Gemifloxacin Mesylate and Levofloxacin Hemihydrate by using selected adsorbents such as charcoal, kaolin, silica gel and alumina. For

equilibrium studies, two adsorption isotherms were used Freindlich and Langmuir. The study showed that maximum adsorption capacity for fluoroquinolones occurred into adsorbent charcoal. The amount adsorbed at equilibrium decreases as adsorbates concentration increased and the weight of adsorbent increases the amount of drug adsorbed increases, **(Hattab, 2010)**.

Chapter Three
Methodology

The research experimental work basically depends on determining the concentration of residues of amoxicillin, ibuprofen, and caffeine versus time in soil, and leachate (underground water) based on times–terms concentration which is considered by three terms, Zero-term, short-term (one year), and long –term concentration (fifteen years).

Samples of soil, wastewater, and leachate were analyzed by UV spectrophotometer and HPLC. The room temperature recorded ranged between 18c˚-25c◦. All glassware used were cleaned and dried before measurement and each measurement of this study was the average of three readings to ensure that consist values were obtained. Standard readings were obtained for amoxicillin, ibuprofen, and caffeine and were plotted against absorbance readings in order to calculate the concentrations of these compounds.

3.1. Material & Methods

This chapter of study addressed on each of the tools that used to implement the experiment, method of work, and materials used in the analysis in addition to the three main drugs which are the subject of study and the mathematical equations needed for the experimental procedures. This chapter will explain the procedure and chemicals for all experiments.

3.1.1 .Chemicals and Reagents

All pharmaceuticals and chemicals were purchased from the Sun Company in Palestine and all chemicals were HPLC grade. The other pharmaceutical materials (samples for studies) were manufactured in Palestine, (Beir zait ,Dar ashefa, Jerusalem pharmaceutical companies in Ramallah).

 The following list is for all chemicals used in this study:

- Pharmaceuticals compound (amoxicillin, ibuprofen, and caffeine).

- Chemicals for HPLC and spectrophotometer.

- Acetonitril.

- Monobasic potassium phosphate.

- Sodium hydroxide.

- Trichloroacetic acid.

- Ammonium hydroxide.

- Glacial acetic acid.

- Sodium acetate.

- Distilled water.

- Reagents

- Potassium dichromate.

- Sulfuric acid.

- - Ammonium Sulfate.

- Potassium hydroxide.

- Copper Sulfate.

- Boric acid.

- Potassium thiosulfate.

- Phenolphthalein.

- Ethylene diamine tetra acetic acid EDTA.

3.1.2 .Instrumentation

Absorbance readings of ibuprofen, amoxicillin, and caffeine were detected using UV-VIS SHIMADZU, Model No: UV-1601, double beam spectrophotometer wave length range 190-1100 nm, accuracy ± 0.004.

The detecting wavelengths for the pharmaceutical compound were confirmed using high performance liquid chromatography (HPLC), (SHIADZU CORPOROATION), with Lichoro CART®, C18 column(250 mm×4mm, 5 μm), Detector DIODE ARRAY. The wave lengths were 254nm, 230nm, and 256nm for ibuprofen, amoxicillin, and caffeine respectively.

3.1.3. Soil Column Preparation

In this study seven soil PVC plastic columns were prepared, with 2meter long and 6 inchs diameter (15.25cm), (Cordy,G.E ., et al, 2004). Sample of soil was collected from $1000m^2$ area located on the north of Jenin district (Marj Iben Amer), far away from any expected source of contamination with any pharmaceuticals type. A 1.0 Kg of soil sample was collected from different sites randomly, mixed, sieved, and filled inside the columns and was analyzed before any treatments. The first column was used as blank using tap water, which is the same water that has been used for preparation of medicines, and added to the soil as in the other columns, as shown in the following figure.

Figure (3.1): Soil column apparatus

3.2. Soil Analysis

One kilogram of soil sample was weighted accurately, sieved in 2.0 mm sieve, and dried at 105 c°. Before any treatment with pharmaceuticals several tests were conducted on soil as the following:

3.2.1. Soil Texture (Hydrometer Test)

The determination of the size distribution of soil particles is known as mechanical or particle size analysis. The particle size distribution of soil expresses the proportions of various size classes (clay ‹0.002mm, silt 0.002-.0.02mm, and sand 0.02-2.0 mm particle size), represented by weight percentages of total soil, using hydrometer method, **(Bouyoucos,G.J., 1962)** .based on the stoke Law,(the law that the force that retards a sphere moving through a viscous fluid is directly proportional to the velocity of the sphere, the radius of the sphere, and the viscosity of the fluid) ,and used to predict the settling times for various sized particles and it states that the rate which particles fall in suspension is directly proportional to their size and the force due to gravity.

The soil was sieved using 2 mm sieve, and dried at 105 c° for 24 hours by Elle oven, and the soil texture was determined by ASTM 152-H hydrometer device.

3.2.2. Moisture

The results of soil analysis are to be calculated on the basis of oven dried sample weight. Therefore, the moisture analysis is executed before any other analysis. The result on basis of air-dry weight was multiplied by a moisture correction factor (mcf), which is a ratio of the dry weight to the wet weight.

A crucible was placed in Ari J.Levy oven at a temperature of 105 c^{o}for 2 hours, then cooled down to room temperature in a desiccators; the weigh the empty crucible was recorded. A 10g of soil sample were weighted and placed at least 12 hours in the oven at 105 c^o, then cooled it down to room temperature in a desiccator and reweighed again. The moisture content for the soil content was calculated using the following equation:

M (moisture content) % = (B-C)/ (C - A) * 100%

Mcf (moisture correction factor) = 100+M% / 100

Where:

A: weight of empty crucible

B: Sample weight + crucible weight before drying.

C: Sample weight + crucible weight after drying, **(Buurman, P., et al., 1996), (Dhyan.S., et al., 1999).**

3.2.3.Specific Gravity

Specific gravity is the ratio of the mass of unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature.

Take 500 mL of distilled water and determined their weight (W1), then weigh out about 100 g of dried soil, and placed in volumetric flask with distilled water. entrapped air by boiling gently for 10 minutes, occasionally rolling volumetric flask to assist in removal of air, cooled the contents at room temperature.

The volumetric flask weight (soil plus bottle plus water) (W2). Using a plastic squeezing bottle, wash the inside of the flask and make sure that no soil is left inside then determine the weight of the dry soil in the evaporating dish(W3).

The specific gravity of soil sample can be calculated by the following equation:

Specific Gravity (Gs) $= W3/(W1+W3) W2$

Where:

W1: Weight of distilled water with flask.

W2: weight of (soil plus bottle plus water)

W3: weight of the dry soil in the evaporating dish.

Specific gravity is generally reported on unit weight of water at temperature

T=20cº.

The specific gravity at (20 cº) = Gs (at T1C)*A with value of A at (20 cº) =1

3.2.4. pH

Add 10 g of air dried of 2 mm sieved sample into 100 ml distilled water and shake for one hour **(Dhyan, S., et al., 1999)**.

The results of moisture, pH, soil texture, specific gravity will be shown in chapter four.

3.2.5. Organic Carbon (Walkely ND Black 1934)

The organic carbon in the sample is oxidized with potassium dichromate and sulphuric acid. The excess potassium dichromate is titrated against ferrous ammonium sulfate.

Weigh accurately 1gram of soil to contain into a dry 500 mL conical flask 10 mL 1 N K2Cr2O7 and 20 mL concentrated H2SO4 were added.

Immediately swirl the flask until the soil and the reagent are mixed. Insert a 200 cº thermometer and heat while swirling the flask and the contents on a hot plate or over a gas burner and gauze until the temperature reaches 135 cᵒ (approximately ½ minute). Then 1ml of diphenylamine indicator

was added and the resulted suspension was titrated against 0.5 N ferrous ammonium sulfate solution until green color started appearing indicating the end point. The carbon content was calculated using the following equation.

$$\text{Organic Carbon (\%)} = 0.003 \text{ g x N x 10 mL x (1 T/S) x100 / ODW}$$

$$= 3(1 - T/S)/ W$$

Where:

N = Normality of K2Cr2O7 solution.

T = Volume of FeSO4 used in sample titration (mL).

S = Volume of FeSO4 used in blank titration (mL).

ODW = Oven-dry sample weight (g).

% of organic matter = 1.72 X % of organic carbon**, (Walkely, A.J., and Black. 1934; Jackson, M.L., 1962).**

3.2.6. Wastewater Analysis

Three pharmaceutical factories in the West Bank discharge their wastewater into the public sewer system with and without prior treatment. All wastewater samples were taken around 9:00 a.m, and collected at the discharge point from these factories in Ramallah.

Wastewater samples were collected in glass containers previously cleaned by washing with non-ionic detergent, rinsed with tap water and later rinsed with distilled water prior to usage.

The samples were labeled and transported to the laboratory, stored in the refrigerator at about 4 c^o prior to analysis as the following:

3.2.6.1. Determination of Chemical Oxygen Demand (COD):

The Chemical Oxygen Demand (COD) test measures the oxygen equivalent consumed by organic matter in a sample during strong chemical oxidation.

2.5 ml of sample was taken into a refluxing flask; 3.5 ml of sulfuric acid H_2SO_4 with 1.5 potassium dichromate ($K_2Cr_2O_7$) were added to the solution.

Digest the tubes for two hours, then cooled at room temperature, and titrated the samples using ferrous ammonium sulfate ($FeNH_4SO_{4)}$ and indicator.

The milliliter equivalent of O_2 is equal the milliliter equivalent of ferrous ammonium sulfate ($FeNH_4SO_4$) FAS. Therefore COD of wastewater samples can be calculated by the following equation:

COD as mg of O_2/L $=$ (A –B) * M* 8000/(sample volume)

Where:

A: ml FAS used in blank

B: ml FAS used in sample

M: morality of FAS

8000: ml equivalent of $O_{2*}1000L/ml$, **(Andrew, E., et al., 1995).**

3.2.6.   2. Determination of Biological Oxygen Demand(BOD)

Biological oxygen demand (BOD) measure the amount of oxygen requires by bacteria for breaking down to simpler substances the decomposable organic matter present in wastewater or treated effluent. It is also taken as a measure of the concentration of organic matter present in any water. The greater the decomposable matter present, the greater the oxygen demand.

Fill three dissolved oxygen bottles with sample wastewater, place the sample bottle in the dark and incubate for five days at 20c°. After five days, the level of dissolved oxygen (in mg/L) of this sample was determined, **(Andrew, E., et al., 1995),** both results of BOD, COD, will be shown in chapter four.

3.2.6.3.Determination of Nitrogen (Kjeldhal Test)

Nitrogen in wastewater is mostly present in an organic form with small quantities of ammonium and nitrate. The samples is first digested in

a catalyst mixture which convert all nitrogen into ammonium sulfate, then the distillation processes of ammonia (librated after sodium hydroxide is add to ammonium sulfate), over boric acid and finally the amount of the ammonia that has been trapped is determined by titration with a standard solution, and a calculation made.

143 ml of concentrated H_2SO_4 to 25ml of wastewater, the sample was allowed to cool, and then a 50 mL of reagent (a mixture of 134 g of potassium sulfate (K_2SO_4), 7.3 grams copper sulfate $CusO_4$ catalysts solution) were added. Cool and dilute to reach one litter, store at room temperature and do not allow salt to precipitate, if precipitation does occur, put reagent bottle in warm water bath for about 30 minutes. Stir on stirrer plate until precipitation is no longer evident. Add 25ml sample of boric acid (The boric acid captures the ammonia gas) into the mixture, forming an ammonium-borate complex (H2BO-3). As the ammonia collects, the color of the receiving solutions changes.

The flask was placed under the condenser of distillation apparatus to separate ammonia–nitrogen from the digestate; this is accomplished by raising the pH with sodium hydroxide 50% (NaOH). This converted the ammonium (NH_4^+) ion to ammonia (NH_3).

Add an indicator to the distilled solution, and titrated with hydrochloric acid HCl "0.1M"to the violet end point. The percent of nitrogen was calculated using the following equation:

%Nitrogen = V (HCl) xM (HCl) Mwt (N) / (V of sample *1000)*100%

N Concentration ppm = %N*10000, (Andrew, E., et al., 1995)

3.2.6.4. Determination of Phosphorus

Phosphorus occurs in natural waters and in wastewaters almost solely as phosphates.

Add 0.5 mL of sulfuric acid to a 100 mL wastewater sample with 15 ml potassium thiosulfate K2SO4 in a 125 mL Erlenmeyer flask. Boil gently on a pre-heated hot plate for approximately 30-40 minutes. Add few drops of phenolphthalein indicator to the sample solution. Acid samples must be neutralized with 1 N sodium hydroxide (40 g NaOH/L), and get pink color, then add distilled water to volume 100ml mark and known (V1).

Take 1 ml of the mixture was added to 4 ml to phosphorus reagent that consist of 0.132 g ascorbic acid were dissolved in 25ml distilled water), then continue the volume to 25 ml (V2). If color is blue this indicates for the presence of phosphorus. A blank test shall be carried out in parallel by the same procedure, using the same quantities of reagent (4ml) and (25ml) distilled water sample.

By using spectrophotometer at 880 nm wave length to measure the concentration of phosphorus.

The concentration of phosphorus can be calculated by using the following equation:

Conc. of phosphorus in ppm = (C$_*$V 1$_*$V2)/ (V1$_*$1000ml) $*$100

Where:

C: Conc. that measured by UV.

V1:100ml

V2:25ml, (Bowman, G.T., and Delfino, J.D., 1982).

3.2.6.5. Determination of Calcium and Magnesium

The titration method using the chelating agent, EDTA (ethylenediamine tetraacetic acid), used to determine both calcium and magnesium.

The titration is conducted under conditions where both ions react with the EDTA, and the end point is detected after both are titrated.

To deter mine magnesium, take 25ml of the wastewater sample in an Erlenmeyer flask then add at least one ml of pH 10 buffer solution (ammonium hydroxide) to the sample. The pH should be 10. To check pH, use standardize pH meter, a few drops Eriochrome Black indicator were added to the Erlenmeyer flask.

Fill the burette with standardized EDTA; begin to titrate the sample two drops at a time. Be careful to titrate slowly near the endpoint, as the color will take about 5 seconds to develop, the endpoint color is blue.

To determine calcium take 25-ml of the water sample into an Erlenmeyer flask, add at least one ml of pH 12 buffer solution (Sodium hydroxide) to the sample. The pH should be 12, to check pH, use standardize pH meter. Add a few drops hydroxynaphthol blue indicator to the Erlenmeyer flask.

Fill the burette with standardized EDTA; begin to titrate the sample two drops at a time. Be careful to titrate slowly near the endpoint, as the color will take about 5 seconds to develop, the endpoint color is blue,**(Andrew, E., et al., 1995).**

The concentration of both calcium and magnesium can be calculated by using the following equations:

Conc. of calcium (ppm) = Volume of EDTA*Mwt(Ca)*M (EDTA)*100

 Volume Sample of *1000

Conc. of Magnesium (ppm) = (Volume of EDTA*Mwt (Mg)*M (EDTA)*100)

Volume Sample of *1000

Determination of Heavy Metals

The analysis of wastewater for trace heavy metal contamination is an important step in ensuring human and environmental health. Spectrophotometric method is the most important for determining heavy metals in wastewater. In comparison with atomic emission spectroscopy,

atomic absorption spectroscopy and similar techniques, it offers the advantage of having calibration graphs that are linear over a wider range.

The heavy metals analyzed in this study included cadmium, chromium, nickel, and zinc using atomic absorption flame emission spectrophotometer instrument.

This served as the stock solution equivalent to 100 ppm. Subsequently lower concentrations of 1 ppm, 2 ppm, 4 ppm and 6 ppm, were prepared from the stock by serial dilution. The same method was adopted for Cr, Ni, Cu and Zn, (**Andrew, E., et al., 1995**).

3. 3. HPLC Scanning of Amoxicillin, Ibuprofen, and Caffeine

A rapid analytical procedure for routine identification and quantification of amoxicillin, Ibuprofen, and caffeine in wastewater by high performance liquid chromatography (HPLC), the processes for detection of these compounds involve three solution preparations (mobile phase, standard, and sample solutions).

3.3.1 HPLC Scanning of Amoxicillin

For detection of amoxicillin use UV at 230 nm, chemicals and reagents (Acetonitril solution, monobasic potassium phosphate, Sodium hydroxide, distilled water, and amoxicillin raw material). In this experiment three solutions will prepared*:*

Mobile phase solution: solution prepared from diluents and acetonitrile (96:4), the diluents was a mixture of (6.9 g of monobasic potassium phosphate with 1000 ml distilled water), adjusted with 45%NaOH solution to pH of 5.0 ±0.1.

The standard solution: it's prepared by dissolving an accurately weighed quantity of amoxicillin raw material in diluents to obtain solution having a known concentration of about 1.2 mg\ml, degassed by ultrasonication before use. The mobile phase was prepared daily (use the solution within 6 hours).

Waste water samples: that were collected from drug manufacturers must be filtered before making injection.

Procedure: separately inject equal volume (10 μ liters) of standard solution into HPLC to take retention time, and then inject equal volume of three sample solutions into same device, with cleaning by mobile phase after each sample.

3.3.1. HPLC Scanning Of Ibuprofen :

For detection ibuprofen use UV at 254 nm, (chemicals and reagents are Trichloroacetic acid, distilled water, ammonium hydroxide, ibuprofen active ingredients material). Three solutions will prepare:

Mobile phase solution: its prepared from 4 grams of trichloroacetic acid with 400 ml distilled water, adjusted with ammonium hydroxide solution

to pH of 3, then 600 ml from acetonitril solution was added, finally filtration for all solution made and degassed by ultrasonication before use .

Standard solution: it's prepared from 0.12 grams of ibuprofen active ingredients with 10 ml volumetric from mobile phase solution and degassed well. In addition to the wastewater samples that collected from drug manufacturers must be filtered before make injection.

Procedure: separately inject equal volume (10 μ liter) of standard solution into HPLC to take retention time, and then inject equal volume of the three samples solution into same device, with cleaning by mobile phase after each sample.

3.3.2. HPLC Scanning of Caffeine

For detection of caffeine use UV at 256 nm, chemicals and reagents are (glacial acetic acid CH_3COOH, distilled water, sodium acetate, caffeine raw materials). As in previous scanning, three solutions prepared which are: Mobile phase solution: 20% CH_3COOH (volume\volume), with 100 ml distilled water buffered to pH 5.08 with saturated sodium acetate solution.

Standard solution: prepare 0.05mg\ml (5ppm) of caffeine raw material. In addition to the waste water samples that were collected from drug manufacturers must be filtered before making injection.

Procedure : separately inject equal volume (10 µ liter) of standard solution into HPLC to take retention time, then inject equal volume of the three samples solution into same device, with cleaning by mobile phase after each sample, (United States Pharmacopeia Convention, Inc. 1995), The following table showed retention time and wavelength for each drug.

Table (3.1): wave length and retention time**:**

Drug's Name	Wave Length(nm)	Retention Time(minute)
Amoxicillin	230	9.16
Ibuprofen	254	2.0
Caffeine	256	20.7

3.4. Calibration Curve

A standard calibration curves for amoxicillin, ibuprofen, and caffeine were performed by preparing diluted solutions from stock solution containing 500mg\L, 50 mg of ibuprofen ,amoxicillin and caffeine reference standards were accurately weighed each of which alone, transferred into 100 ml volumetric flasks, mobile phase solution was added to volume and stirred until completely dissolved. Several dilutions were made of each of them by taking 1ml(10ppm), 3ml(30ppm), 4ml(40ppm),

6ml(60ppm) and 8ml(80ppm) from stock solution and transferred into 50 ml volumetric flasks, distilled water was added to volume. Absorbance readings were recorded at 254nm for ibuprofen, 230 nm for amoxicillin, and at 256 nm for caffeine.

3.5. Isotherms

The most widely used equation to fit empirical data from solute – solvent adsorbent system is the Freundlich equation. Due to its simplicity and versatility in fitting data from systems, Freundlich relationship will be used in this study to describe the quantitative adsorption of ibuprofen, amoxicillin, and caffeine onto soil.

Four different concentrations 50ppm, 40ppm, 30ppm, 20 ppm and of each drug solutions were prepared, each in 125 ml Erlenmeyer flask, 5 grams of oven-dried sieved sample were added to each flask, 50 ml of each concentration for each substance were added to each flask, all samples were covered with teflon screw caps and mounted on Comfort Hetro Master Shaker for 24 hrs. Soil was left to settle, and centrifuged at 3000 rpm for 10 minuts. Absorbance readings were recorded at 254nm for ibuprofen, 230nm for amoxicillin and at 256 nm for caffeine sample solutions using UV-1601 PC, SHIMADZU spectrophotometer.

3.6. The Effect of Temperature on (Amoxicillin, Ibuprofen, and Caffeine) -Soil Adsorption

The purpose of this task is to determine the effect of temperature on the process of hydrolysis and adsorption of amoxicillin, ibuprofen, and caffeine onto soil.

Stock solutions of amoxicillin, ibuprofen, and caffeine (500mg\L) were used as a dsorbate and solution of 50 ppm (50mg\L) concentration were obtained by diluting the stock solution with distilled water.

In the kinetic experiments for Ibuprofen, 50ppm was prepared from stock solution (1ml of ibuprofen solution/10ml distilled water) was mixed with 10 gram of oven dried sieved soil in 100ml volumetric flask. The adsorbent and a dsorbate suspension were separated by shaking and by centrifugation at 3000 rpm for 10 minutes using Hermel Z200A Centrifuge. Thermodynamic study of adsorption experiments were performed following the same procedure at 15 c°, 25 c°, and 35c°. Then the supernatants were filtered through filter paper and the three drugs concentrations were analyzed using UV-1601 PC, SHIMADZU spectrophotometer at different time (10, 30, 60, 120,and 180 minutes) to show the effect of contact time of their uptake by the adsorbent (soil) .

To determine the concentrations of thesis pharmaceuticals that adsorbed on soil by subtracted the concentration in the supernatant solution from the origin one (50ppm) then plotted graphs of the pharmaceutical

concentration versus time intervals. Finally plot the curve as Time on x-axis and the concentration Y-axis, **(Sruchi M. K., 2011).**

3.7. The Effect of pH on (Amoxicillin, Ibuprofen, and Caffeine) -Soil Adsorption.

The purpose of this experiment is to determine the extent to which adsorption was influenced by varying pharmaceutical ionization state and aquifer material surface properties with varying pH, and the properties of the pharmaceuticals and surfactants studied. So we have to do the following:

Take the 50 ppm sample of each drug and mix it with 10 g of the soil sample and use 0.1 M HCL to acidify the solution be sure the final PH is about "1.5". Do the same thing but change the pH to 4 then you already have it at 7 then use NaOH 0.1M) to have it 12. Keep in mind the concentration stays 50 ppm. Then shake it for 60 min and keep the temperature at 25c°.

Centrifuging the samples, filtering them using Whatman filter papers "no. 42" and measuring the concentration of the drugs using spectrophotometer, use the calibration curve that was made in (Kinetic and Isotherms of amoxicillin, ibuprofen, caffeine) experiment. Finally plot the curve as pH on x-axis and the concentration Y-axi,(**Hari, A.C., et al., 2005),** the results will shown in chapter four.

3.8. Amoxicillin, Ibuprofen, and Caffeine Application to Soil Column Experiment

Seven columns were prepared for the pollution process, two columns for each drug was labeled according to the pollutant type, quantity and time. The first column was considered as blank, i.e. hasn't any pharmaceuticals, but tap water was added to it. The second one was polluted with Ibuprofen; a solution containing (0.2034) gram of Ibuprofen/4L) contained 50mg/L was prepared and added to the column, therefore it was labeled (ibuprofen one-year), the third column contained (3.054) gm of Ibuprofen powder 4\L contained 50mg/L of ibuprofen, a product of the Palestinian Companies for Pharmaceuticals, Ramallah).

The third and four columns were polluted using amoxicillin contained of 50 mg\L, solution containing 0.2034 g for one year and 3.054 for 15-years. The fifth and sixth columns were polluted using caffeine 50mg\L solution containing 0.2034 g for one year, and 3.054 for 15-years. After the addition of pharmaceuticals to the columns, Soil columns were left for 24 hrs to ensure a complete adsorption process on soil.

3.9. Collecting and Storage of Leachate Water Samples

Water samples were collected and kept in well closed HDPE plastic bottles, and stored in a refrigerator (at 7c°). HDPE plastics are known for their low adsorption properties, low moisture absorption, and high tensile strength. HDPE is also non-toxic and non-staining and meets FDA and USDA certification, (http://www.boedeker.com/polye_p.htm;Boedeker Plastics, Inc. Polyethylene Specifications Texas / USA).

Leach ate water was centrifuged to remove solid particles and then the supernatant was filtered using Whatman filter papers no "42" before analysis.

3.10. Distribution of Pharmaceutical in Soil Columns after Finishing the Leachate Study:

At the end of the experiment, each soil column was cut into eight parts (0-25cm, 25-50cm, 50-75cm, 75-100cm, 100-125cm, 125-150cm, 150-175cm, 175-200cm .

The soil samples were prepared as follows: 20 gm of polluted soil were weighed and transferred in to 250 ml conical flask, 100 ml of distilled water were added and stirred for 30 minutes using Freed Electric magnetic stirrer, the suspension was filtered through Whatman filter papers "no. 42", and measured the concentration using spectrophotometer.

Chapter Four

4. Results & Discussion

The results of this work are represented in tabular and graphical form. Results were devoted to understand the behavior and the fate of amoxicillin, ibuprofen, and caffeine in soil and underground water for the next 15 years, including their adsorption in soil. Discussion of the results follows each part of experimental work.

4.1. Soil Tests

Samples of red soil were analyzed in order to evaluate the soil texture, moisture, pH value, and specific gravity. Table" 4.1" shows the results obtained from these tests.

Table (4.1): Soil specific gravity, pH, texture, and moisture for soil before pollution.

Soil Properties	Result
Specific Gravity	2.34
pH value	7.14
Clay (%)	41%
Silt (%)	59%
Moisture content	9.5%
Organic Carbon %	2.34%
Organic Matter %	4.36%

From the table above it was noticed that the silt percentage is larger than that in the clay , organic carbon and organic matter are less than the percentage that increase the adsorption (3%, 5%) respectively ,which indicates that low percentage of adsorption will occur.

4.2. Waste water Test

Samples of wastewater from three pharmaceuticals industrial companies were collected and analyzed in order to evaluate the following:

4.2.1. pH, BOD, COD

Table (4.2): wastewater PH, BOD and COD

Company Name	pH	BOD mg\L	COD mg\L
Alquds	6.62	189.00	5440.00
Dar Alshefa	5.74	210.00	11200.00
Beir –zait	7.44	91.00	64.00

From the table above it was noted that pH in both Dar Alshefa, Alquds companies is acidic, which indicates that these companies used acidic materials in the process of preparation of medicines, and low bacterial level in their wastewater, a while the pH in Beir –Zait company is around neutral .

The rate of COD in Dar Alshefa and Alquds companies is higher than BOD in comparison with Beir-Zait Company, and this shows that thesis companies use chemical treatment for waste water, and they had manufactured a batch of antibiotics in the same day of sample collection. It was also known that wastewater containing antibiotics characterized by the high proportion of COD and low BOD, which is difficult to make biological treatment, **(Elmolla, E., and Chaudhuri, M., 2009)**, this is consistent with the information that was known about the mechanism of the companies wastewater treatment when I visited them.

4.2.2.Calcium, Magnesium ,Phosphorus, Nitrogen:

Table (4.3): wastewater Ca, Mg, P, N.

Company Name	Ca ppm	Mg ppm	P ppm	Nitrogen ppm
Alquds	973.00	51.66	ND	85.00
Dar Alshefa	158.00	88.50	ND	105.00
Beir –zait	121.68	3.69	ND	89.80

It is noted from the table above that there is arising in the concentration of both calcium and magnesium in wastewater collected from the pharmaceutical manufacturing companies, this may be due to the use of some materials in drug filling phase which contains calcium and

magnesium, or manufacturing other types of drugs that also contain calcium and magnesium especially drugs used to treat osteoporosis.

For nitrogen, it is normal to note increase in concentration and this is due to the presence of bacteria whether dead or alive in the wastewater.

4.2.3. Heavy metals (Cadmium, Chrome, Zinc, Nickel).

Table (4.4): Heavy metals concentrations in the three pharmaceuticals companies' wastewater:

WHO Standards		Company name	(Cr) conc. ppm	(Cd) conc. ppm	(Zn) conc. Ppm	(Ni) conc. ppm
Cr ppm	0.050					
Cd ppm	0.003	Alquds	0.050	0.017	0.003	ND
Zn ppm	4.000	Dar Alshefa	0.054	0.037	0.005	ND
Ni ppm	0.020	Beir-zait	0.054	0.044	0.002	ND

It has been observed during the examination of heavy metals for the three pharmaceutical companies the chromium was among the WHO acceptable maximum of (0.05 mg\L), while cadmium concentrations were found to be higher than the WHO acceptable maximum of 0.003 mg/L, so cadmium toxicity has been reported to cause food poisoning, mutation, hypertension, and cancer among others, long term exposure to cadmium has been found to cause serious damage to kidney, liver, bone and blood, **(Anyakora,Ch., et al., 2011),** but Zn concentration in the three companies

was lower than the WHO acceptable maximum of 3-5mg\L, and nickel heavy metal was not detected in the three companies .

4.2.4. HPLC Scanning of Ibuprofen, Amoxicillin, and Caffeine Concentrations

The purpose of this task is for identification and quantification of amoxicillin, ibuprofen and caffeine in the pharmaceutical wastewater companies using HPLC, their retention time, and the wave length of the

previous drugs, then adopted thesis wave lengths to measure the concentrations of drugs from soil lactates. The following table shows the retention time for ibuprofen, amoxicillin, and caffeine.

Table (4.5): Retention time and peaks length and wave lengths of ibuprofen, amoxicillin, and caffeine in pharmaceutical wastewater companies.

Company name	Standard	Alquds	Dar Alshefa	Beir –zait
Amoxicillin				
Retention Time(minutes)	9.16	-	-	-
Wave length	**230nm**			
Ibuprofen				
Retention Time(minutes)	2.00	-	-	-
Wave length	**254nm**			
Caffeine				
Retention Time(minutes)	20.70	-	-	-
Wave length	**256nm**			

4.3 The Effect of Temperature on the Adsorption of (Amoxicillin, Ibuprofen, and Caffeine –Soil).

Absorbance reading and calibration curve for amoxicillin, ibuprofen, and caffeine were recorded at 230 nm, 254 nm, and 256 nm respectively, in addition to measuring of their concentrations at different temperatures, as shown in the following tables and figures.

Table (4.6): Amoxicillin standards at 230nm:

Standard concentration (ppm)	Absorbance
10	0.315
30	0.691
40	0.841
60	1.185
80	2.033
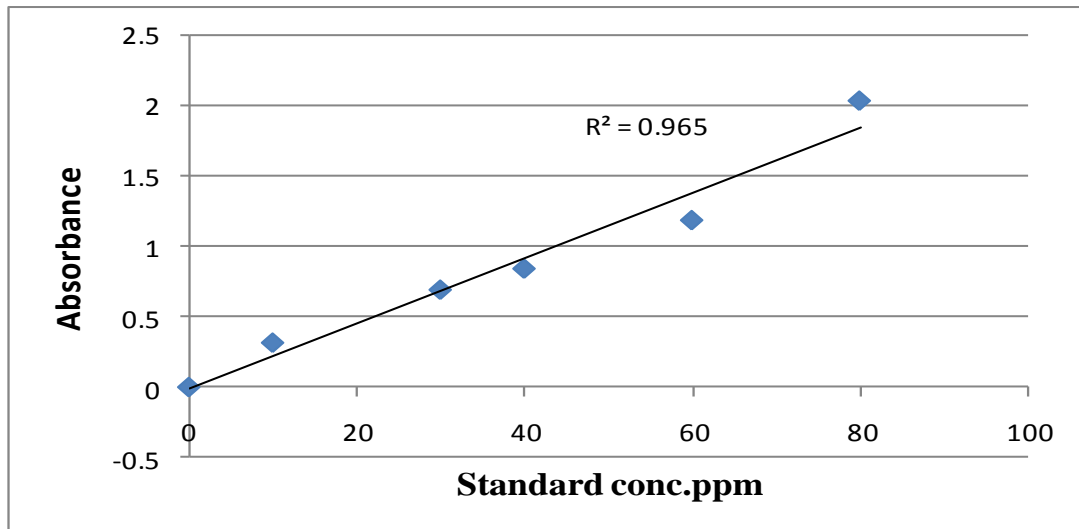
Figure (4.1): Plot of amoxicillin calibration curve.

Table (4.7): Amoxicillin   concentration in supernatant and soil-adsorption at 10, 30, 60, 120,180 minutes:

Concentration .ppm	10min	30min	60min	120min	150min
At 15cᵒ					
Supernatant conc.	8.820	7.570	5.026	4.920	4.606
Soil adsorption	41.180	42.430	44.974	45.080	45.394
At 25cᵒ					
Supernatant conc.	5.206	4.670	3.020	4.350	3.942
Soil adsorption	44.794	45.330	46.980	45.650	46.058
At 35cᵒ					
Supernatant conc.	2.450	1.590	0.750	1.920	3.871
Soil adsorption	47.55	48.410	49.250	48.080	46.129

Table (4.8): Ibuprofen Standards at 254nm:

Standard concentration (ppm)	Absorbance
10	0.007
30	0.021
40	0.039
60	0.068
80	0.102

Figure (4.2): Plot of Ibuprofen calibration curve

Table (4.9): Ibuprofen concentration in supernatant and soil-adsorption at 10, 30, 60, 120,180 minutes:

Standard concentration (ppm)	Absorbance
10	0.406
30	0.903
40	1.401
60	2.061
80	2.537

Table (4.10): Caffeine Standards at 256nm:

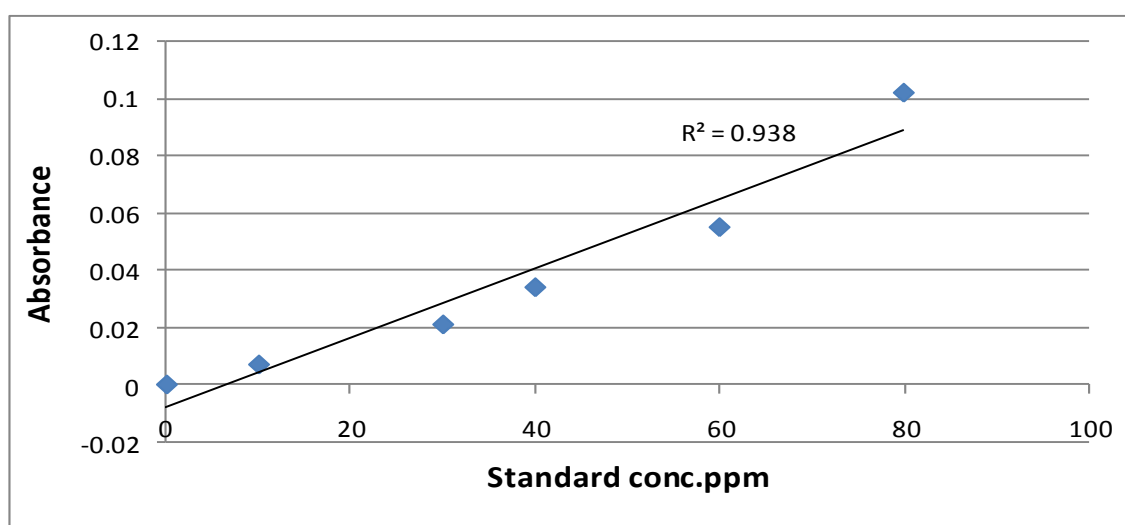| Concentration .ppm	10min	30min	60min	120min	150min
At 15cº					
Supernatant conc.	9.785	8.732	7.020	7.047	7.120
Soil adsorption	40.215	41.268	42.980	42.953	42.880
At 25cº					
Supernatant conc.	9.514	7.321	5.960	6.062	6.995
Soil adsorption	40.486	42.679	44.040	43.938	43.005
At 35cº					
Supernatant conc.	7.020	5.880	3.820	4.016	3.910
Soil adsorption	42.980	44.120	46.180	45.984	46.090

Table (4.11): Caffeine concentration in supernatant and soil-adsorption at 10, 30, 60, 120,180 minutes:

Concentration .ppm	10min	30min	60min	120min	150min
At 15co					
Supernatant conc.	16.243	15.326	11.238	13.560	14.480
Soil adsorption	33.757	36.674	38.762	36.440	35.520
At 25co					
Supernatant conc.	15.515	14.293	12.860	12.970	13.240
Soil adsorption	34.485	35.707	37.140	37.030	36.760
At 35co					
Supernatant conc.	19.896	17.926	14.250	16.018	21.503
Soil adsorption	30.104	32.074	35.750	33.982	28.497
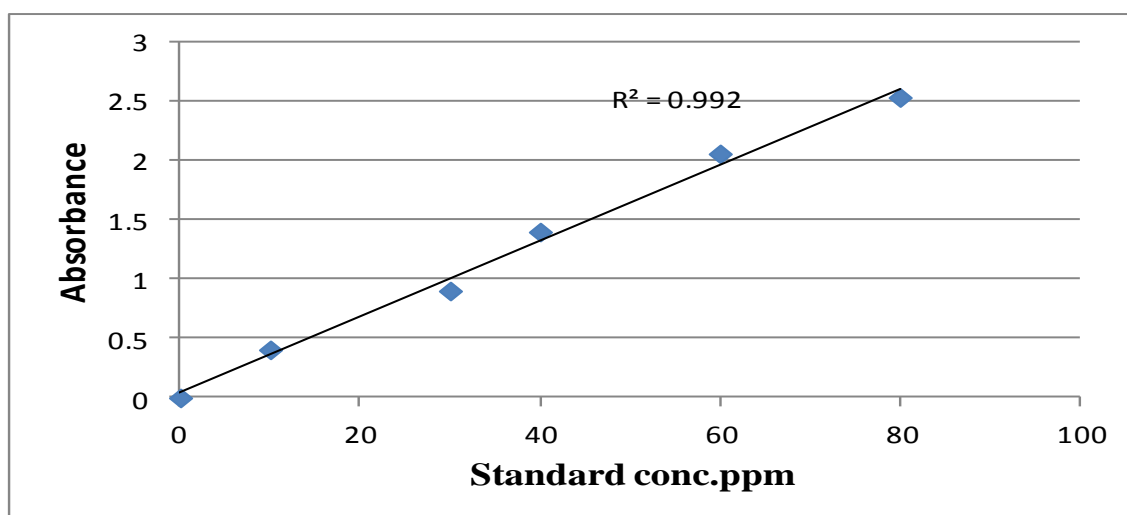
Figure (4.3): Plot of caffeine calibration curve.

Table (4.12): Soil- adsorption of amoxicillin, ibuprofen, and caffeine at temperature 15°c.

Drugs-Soil Adsorption conc.ppm	Time .minutes				
	10	**30**	**60**	**120**	**150**
Amoxicillin	41.180	42.430	44.974	45.080	45.394
Ibuprofen	40.215	41.268	42.980	42.953	42.880
Caffeine	33.757	36.674	38.762	36.440	35.520
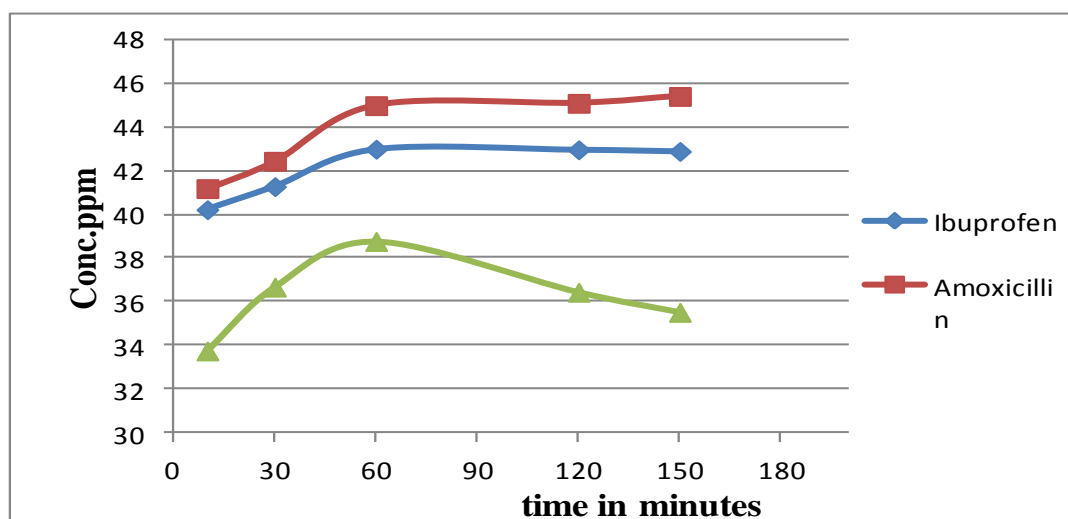
Figure (4.4): plot of concentrations of amoxicillin, ibuprofen and caffeine in soil at 15°c.

Table (4.13): Soil-adsorption of amoxicillin, ibuprofen, and caffeine at temperature 25$\overset{\circ}{c}$.

Drugs-Soil Adsorption conc. ppm	Time .minutes				
	10	**30**	**60**	**120**	**150**
Amoxicillin	44.794	45.330	46.980	45.650	46.058
Ibuprofen	40.486	42.679	44.040	43.938	43.005
Caffeine	34.485	35.707	37.140	35.030	34.760
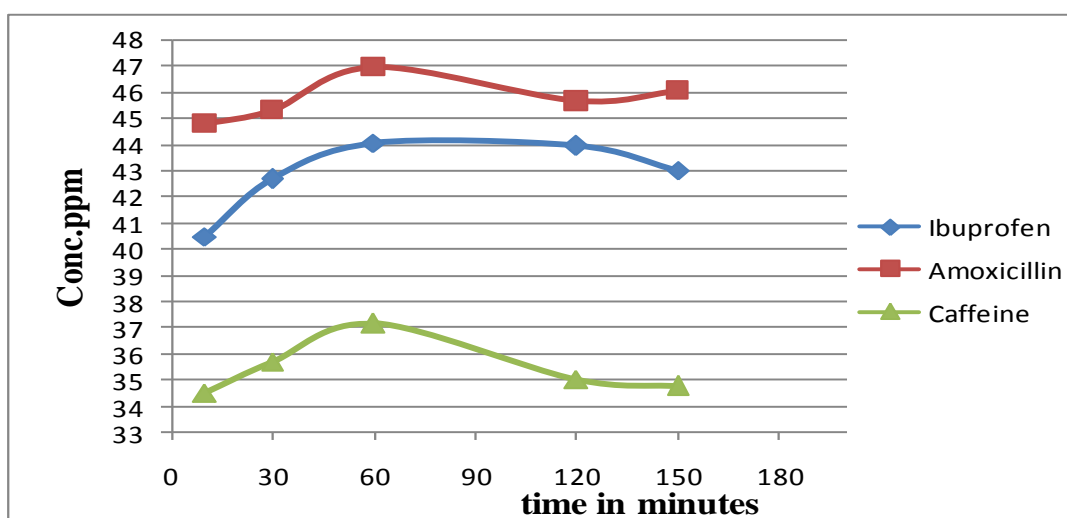
Figure (4. 5): plot of concentrations of amoxicillin, ibuprofen, and caffeine in soil at 25$\overset{\circ}{c}$.

Table (4.14): Soil- adsorption of amoxicillin, ibuprofen, and caffeine at temperature 35$\overset{0}{c}$.

Drugs-Soil Adsorption conc.ppm	Time .minutes				
	10	**30**	**60**	**120**	**150**
Amoxicillin	47.550	48.410	49.250	48.080	46.129
Ibuprofen	42.980	44.120	46.180	45.984	46.090
Caffeine	30.104	32.074	35.750	33.982	28.497
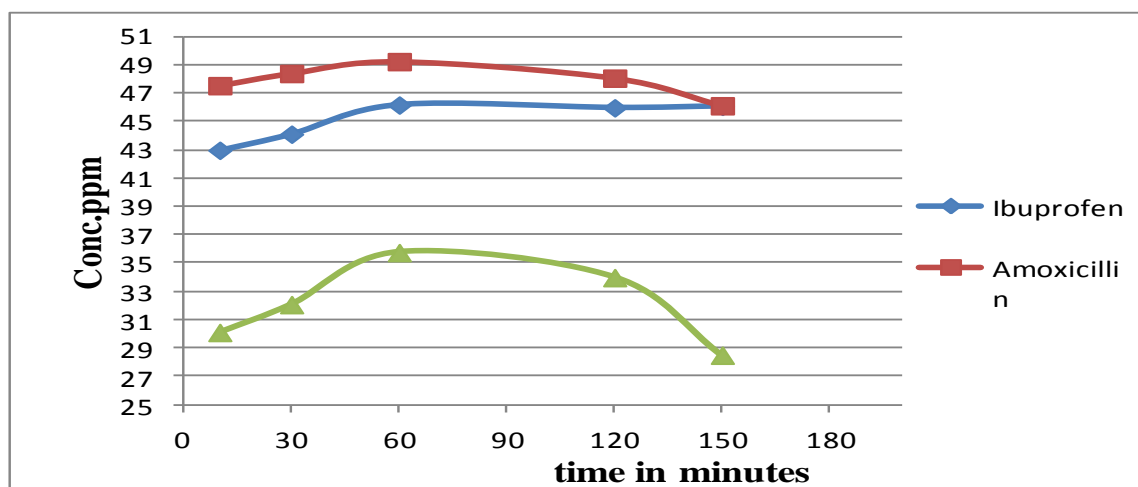
Figure (4.6): plot of concentrations of amoxicillin, ibuprofen, and caffeine in soil at 35c °.

To clarify the extent of the impact of temperature on the adsorption of drugs versus time on the soil, concentrations measured after different time intervals of incubation, the degradation of the selected pharmaceuticals was also influenced by microbial activities, oxygen status in the soil, soil type and compound characteristics. The study showed that the concentrations of

ibuprofen, amoxicillin in the supernatant are decreased with increasing in their adsorption on soil for the first hour, then started to decrease in their adsorption due to its starting degradation, for this reason it's written on the medicine must be kept cool place, **(Dwivedia, A., et al, 2011)**. While the more decreasing of soil adsorption for caffeine with increasing temperature after the first hour because it considered as hydrophilic compound and dissolves in water.

4.4.   The Effect of pH on Drug-Soil Adsorption

The extent to which adsorption was influenced by varying pharmaceutical ionization state and aquifer material surface properties with varying pH will be shown in following tables and figures:

Table (4.15): Amoxicillin adsorption on soil at different pH, constant temperature 25$\overset{\circ}{c}$ and one hour.

Amoxicillin pH	1.500	4.000	7.000	12.000
Supernatant concentration(ppm)	6.020	8.026	7.982	4.856
Soil adsorbed concentration (ppm)	43.98	41.974	42.018	45.144
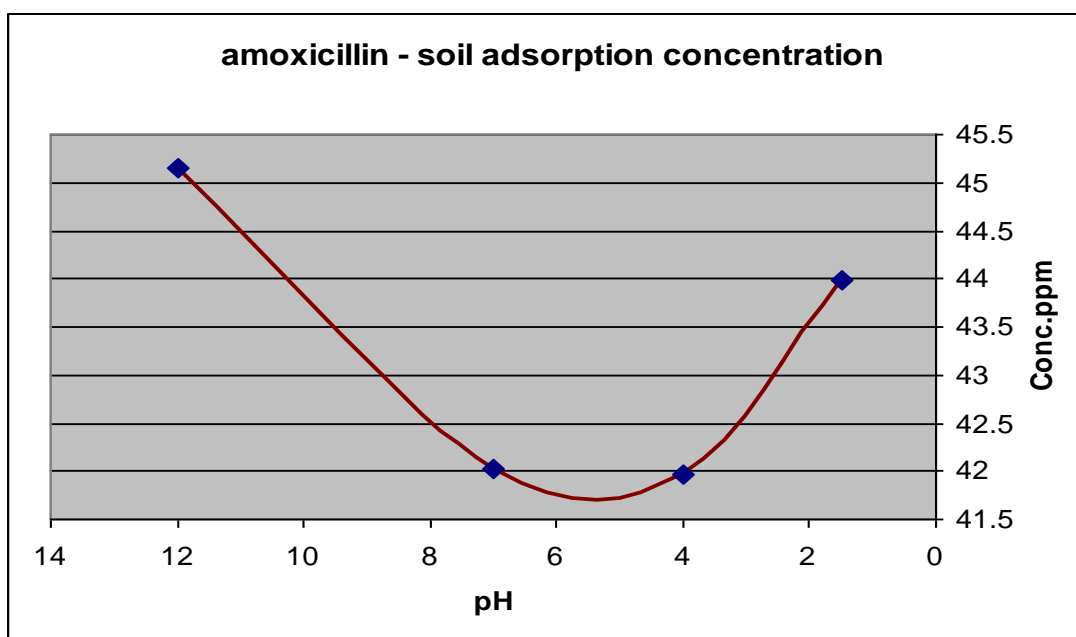
Figure (4.7): plot of soil adsorption concentrations of amoxicillin in soil at different pH, temperature 25c° and one hour.
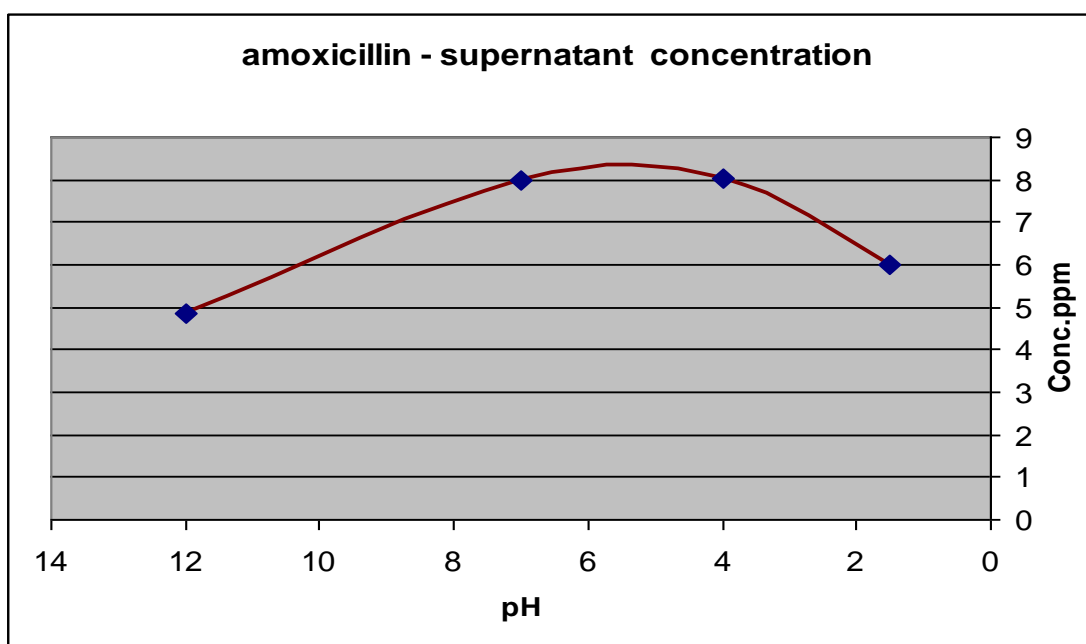
Figure (4.8): plot of concentrations of amoxicillin in supernatant at different pH, temperature 25c°, and one hour.

Table (4.16): Ibuprofen adsorption on soil at different pH and constant temperature 25c̊, and one hour.

Ibuprofen pH	1.500	4.000	7.000	12.000
Supernatant concentration(ppm)	3.930	4.852	6.147	12.892
Soil adsorbed concentration (ppm)	46.074	45.148	43.853	37.108

Figure (4.9): plot of soil adsorption concentrations of ibuprofen at different pH, temperature 25c̊ and one hour.

Figure (4.10): plot of concentrations of ibuprofen in supernatant at different pH, temperature 25c°and one hour.

Table (4.17): Caffeine adsorption on soil at different pH, constant temperature   25$\overset{0}{c}$ and one hour.

Caffeine pH	1.500	4.000	7.000	12.000
Supernatant concentration(ppm)	15.996	6.926	4.295	1.932
Soil adsorbed concentration (ppm)	34.004	43.074	45.741	48.068

Figure (4.11): plot of soil adsorption concentrations of caffeine in soil at different pH ,temperature 25c̊, and one hour.
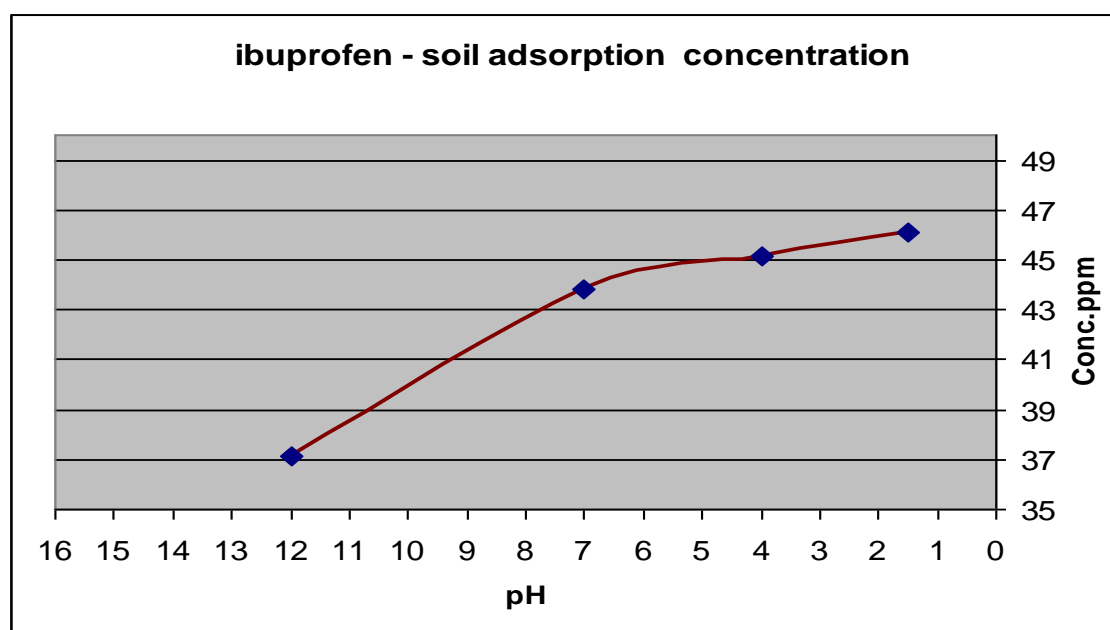

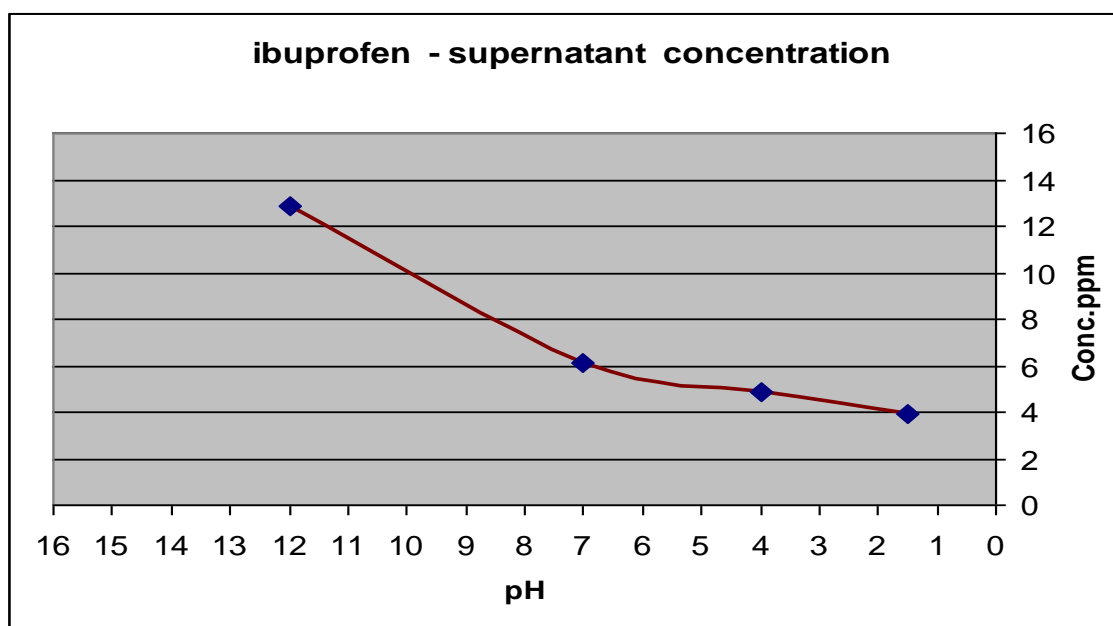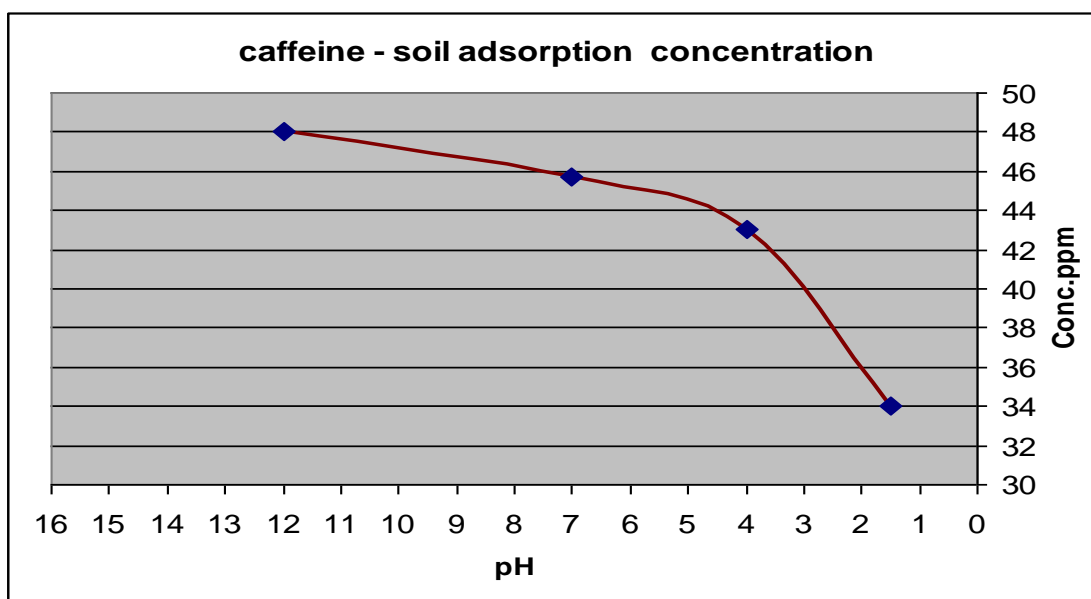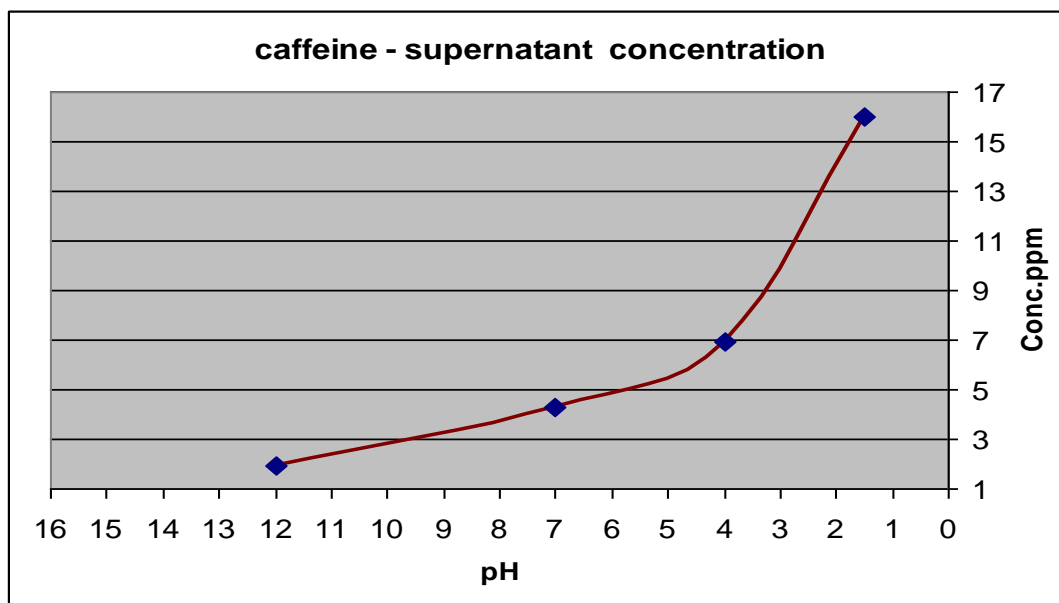**Figure (4.12):** plot of concentrations of caffeine in supernatant at different pH, temperature 25c̊ and one hour.

Table (4.18): Soil adsorption concentration of ibuprofen, amoxicillin and caffeine at different pH, constant temperature 25č and one hour.

pH	1.500	4.000	7.000	12.000
Amoxicillin	43.98	41.974	42.018	45.144
Ibuprofen	46.074	45.148	43.853	37.108
Caffeine	34.004	43.074	45.741	48.068
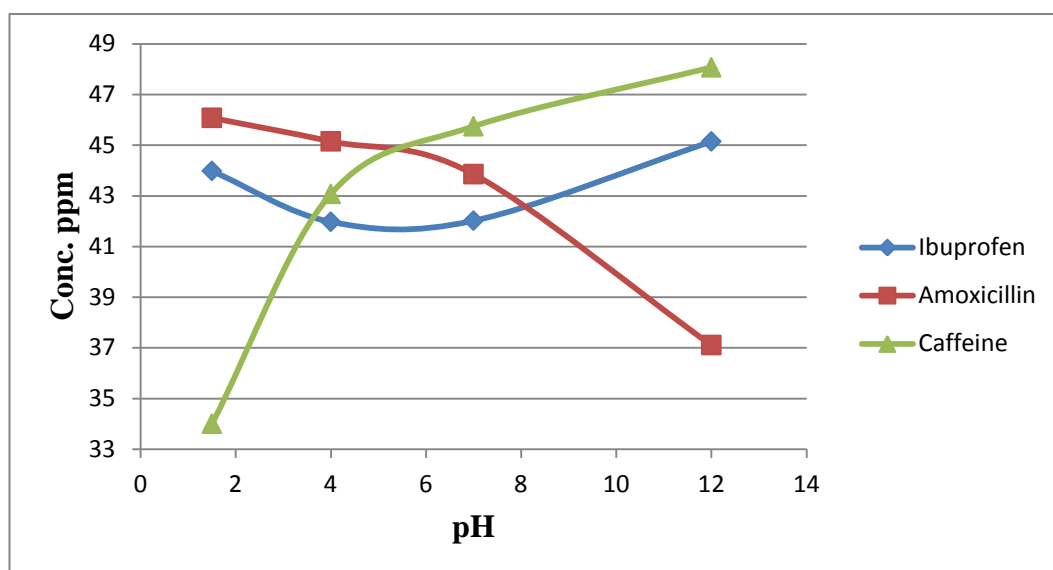
Figure (4.13): Plot of soil adsorption concentrations of ibuprofen, amoxicillin and caffeine at different pH, constant temprature25č and one hour.

The adsorption and hydrolysis of the selected pharmaceuticals was influenced by pH and time , as clearly seen in table (4.15), figures (4.7, 4.8), the highest hydrolysis of amoxicillin was at acidic condition, pH(1.5, 4), and its hydrolysis decreased at neutral to alkaline condition pH(7-12), while the highest amoxicillin soil adsorption at pH (1.5,12)

conditions with more stable over the pH range 4.0–7.0, this due to two facts, the first is the presence of large quantities of OH^- ions on the catalysis surface as well as in the reaction medium favors the formation of OH• radical. Second is the hydrolysis of these antibiotics since instability of β-lactam ring at high pH, **(Elmolla, E., and Chaudhuri, M., 2009)**, but its hydrolysis didn't affected at neutral pH.

The study showed that the soil adsorption efficiency of ibuprofen was more efficient under acidic at pH (1.5and 4) and neutral condition than that in alkaline media as shown in table (4.16), figures (4.9, 4.10), this due to that it consists of hydrophilic and hydrophobic feature, and has dipolar nature of its functional group, with pKa value of 4.91, so the carboxyl group of ibuprofen should be at least partly protonated leading to a sorption onto soil particles. While the maximum hydrolysis of ibuprofen was observed in the pH range of 7-12, due to the presence carboxylic group in its structure, this has been demonstrated in several studies, **(Zheng,J.P., et al., 2011); (Dwivedi, A., et al., 2011); (Oppel, J., et al, 2003).**

In table (4.17), figure (4.11, 4.12), the results showed that the lowest of caffeine soil adsorption concentration was at acidic conditions pH 1.5, 4, and increased at alkaline pH 12, and this is due to caffeine is an acidic compound and dissolves in acidic media, **(Lim,L., and Go,M., 2000),** and tend to more binding with carboxylic group at alkaline condition .

4.5. Adsorption Isotherms

Freundlich adsorption equation is perhaps the most widely used mathematical description of adsorption in aqueous systems, while the Langmuir adsorption isotherm is commonly applied to monolayer chemisorption of gases.

To apply the Freundlich Equation on our work various concentrations of pharmaceuticals ranging between (20-50) ppm were adsorbed at constant weights of soil after 24 hours of adsorption. The equilibrium adsorption data could be described by the Freundlich adsorption equation (1.4).

The isotherm equilibrium results are shown in tables (4.19- 4.23) and figures (4.14-4.17), as the amount adsorbed against the equilibrium concentrations. Readings were recorded until 36 hours; no changes in concentrations were observed after 24 hours for all samples, i.e. its reached equilibrium at 24 hours.

Table (4.19): The application of freundlich isotherm for the adsorption of ibuprofen on soil after 24 hours.

Ci. ppm	Cs. ppm	Log Ci .ppm	Log Cs. ppm
1.230	18.750	0.097	1.273
1.982	26.120	0.297	1.417
2.089	34.670	0.320	1.545
3.706	46.238	0.569	1.665
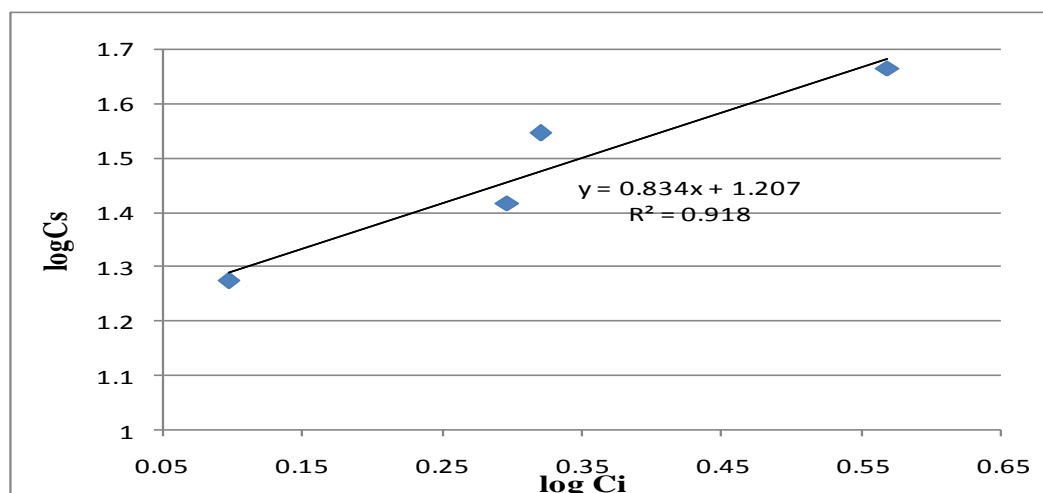
Figure (4.14): The application of freundlich isotherm for the adsorption of ibuprofen on soil after 24 hours.

The Langmuir adsorption isotherm is commonly applied to monolayer chemisorptions of gases. This isotherm is mainly applied when no strong adsorption is expected and when the adsorption surface is uniform.

Table (4.20): The application of Langmuir isotherm for the adsorption of ibuprofen on soil after 24 hours.

Ci. ppm	Cs. ppm	1\Ci .ppm	1\Cs .ppm
1.064	18.940	0.940	0.053
1.570	28.430	0.935	0.0352
1.094	38.910	0.914	0.026
1.110	48.890	0.900	0.020
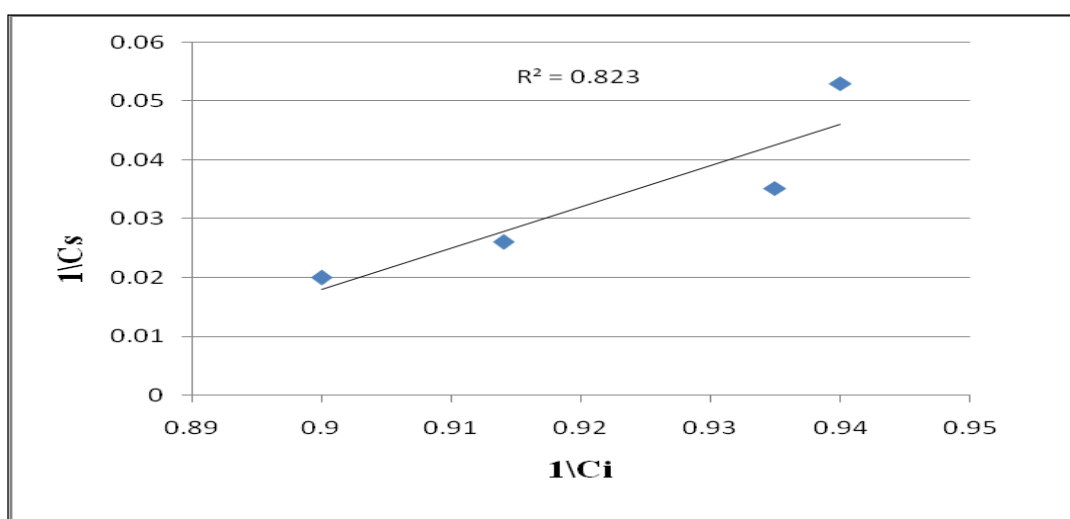
Figure (4.15): The application of Langmuir isotherm for the adsorption of ibuprofen on soil after 24 hours.

Table (4.21): The application of freundlich isotherm for the adsorption of amoxicillin on soil after 24 hours.

Cs.ppm	Ci. ppm	Log Cs.ppm	Log Ci.ppm
18.091	1.909	1.257	0.281
27.400	2.594	1.437	0.414
36.681	3.319	1.564	0.521
45.045	4.955	1.654	0.695
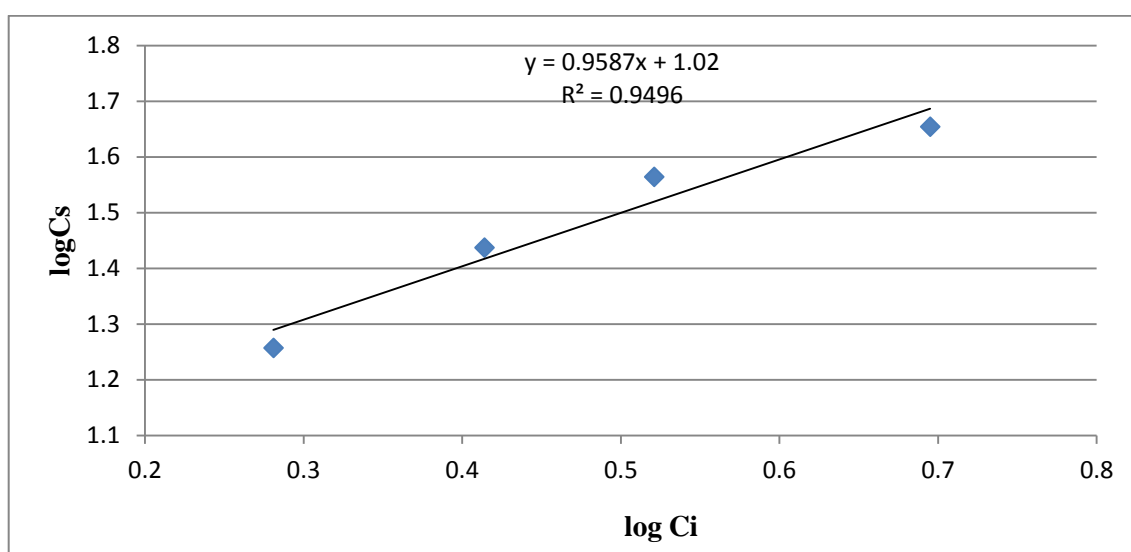
Figure (4.16): The application of freundlich isotherm for the adsorption of amoxicillin on soil after 24 hours.

Table: (4.22): The application of freundlich isotherm for the adsorption of caffeine on soil after 24 hours.

Cs	Ci	Log Cs	Log Ci
17.327	2.673	1.239	0.427
26.419	3.581	1.422	0.554
36.109	3.891	1.558	0.590
46.870	4.130	1.662	0.616
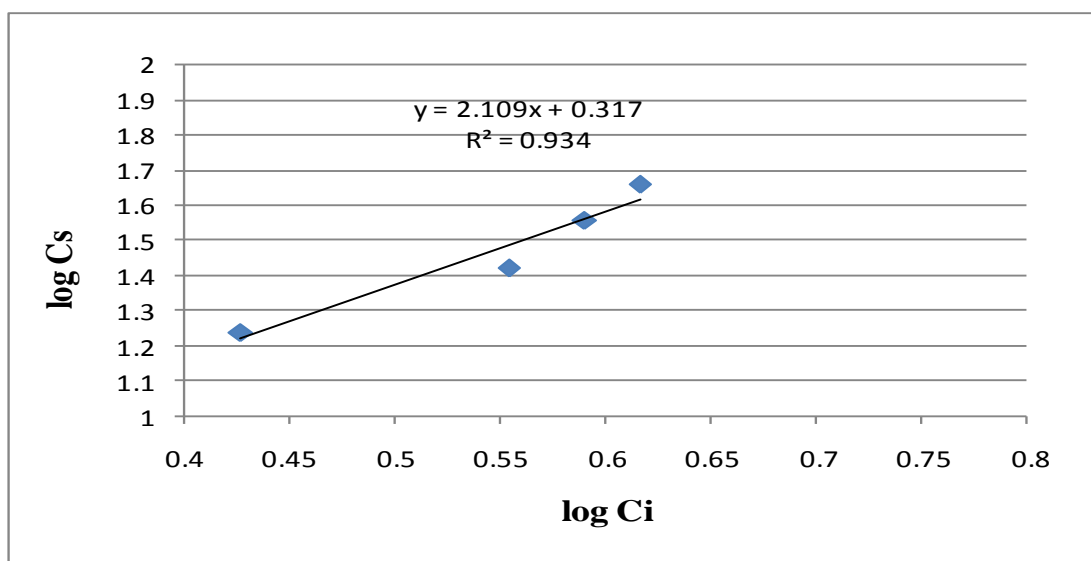
Figure (4.17): The application of freundlich isotherm for the adsorption of caffeine on soil after 24 hours.

Table (4.23): Freundlich isotherm constants (k & n) and the correlation coefficient R for ibuprofen, caffeine, and amoxicillin.

Substances	k	1/n	n	R^2	R
Ibuprofen	1.207	0.834	0.829	0.918	0.958
Caffeine	0.317	2.109	0.474	0.934	0.966
Amoxicillin	1.020	0.958	1.044	0.949	0.974

Both the Freundlich and Langmuir adsorption isotherms showed linear relationship on the present results shown in figures (4.14), (4.15), (4.16), (4.17) for the Freundlich and Langmuir adsorption isotherms, respectively but R^2 for the Freundlich adsorption isotherms is larger than that in Langmuir adsorption isotherms, R values (correlation coefficient) of the three pharmaceuticals readings were close to 1, so the application of

the Freundlich adsorption isotherms was more appropriate. K, n values for the caffeine is lower than "1" which indicate that the adsorption capacity and intensity respectively were low, and it leaves the soil quickly, **(Dwivedia,A., et al ., 2011); Putra ,E.K., et al., 2009); Sotelo,J.L., et al., 2011).**

4.6. Polluted leachate Water from Ibuprofen, Amoxicillin, and Caffeine Analysis

The leachate water that flowed from each soil column was kept in well closed HDPE containers, (http://www.boedeker.com/polye_ p.htm) and stored in refrigerator (at 7c°), all were analyzed by UV-Vis spectrophotometer, absorbance readings were recorded, then transformed into concentrations (ppm) using standard calibration curves, then all were plotted against time. Figures from (4.21- 4.26) shows a plot of ln [A] vs. time, where A is the concentration of ibuprofen, amoxicillin, and caffeine in ppm,   tables (4.24 - 4.26) shows the concentration [A] measured in (ppm) for one year &15-years versus time in days.

Table (4.24): Measured concentrations of polluted water flowed from amoxicillin versus time:

Time	0ne- year		15-year	
Days	[A] ppm	ln[A]	[A] ppm	Ln[A]
1	$9.59*10^{-2}$	-2.34	$16.25*10^{-2}$	-1.80
4	$8.47*10^{-2}$	-2.47	$16.0*10^{-2}$	-1.83
7	$8.04*10^{-2}$	-2.52	$15.66*10^{-2}$	-1.85
10	$7.43*10^{-2}$	-2.60	$15.09*10^{-2}$	-1.89
13	$7.06*10^{-2}$	-2.65	$14.77*10^{-2}$	-1.91
16	$6.89*10^{-2}$	-2.68	$14.14*10^{-2}$	-1.96
19	$6.50*10^{-2}$	-2.73	$13.58*10^{-2}$	-2.00
22	$5.66*10^{-2}$	-2.87	$12.34*10^{-2}$	-2.09
25	$5.05*10^{-2}$	-2.99	$12.21*10^{-2}$	-2.10
28	$4.79*10^{-2}$	-3.04	$11.15*10^{-2}$	-2.20
31	$4.44*10^{-2}$	-3.11	$10.67*10^{-2}$	-2.24
34	$4.24*10^{-2}$	-3.16	$10.37*10^{-2}$	-2.27
37	$3.98*10^{-2}$	-3.22	$9.83*10^{-2}$	-2.30
40	$3.48*10^{-2}$	-3.36	$8.65*10^{-2}$	-2.45
43	$3.10*10^{-2}$	-3.50	$7.43*10^{-2}$	-2.60
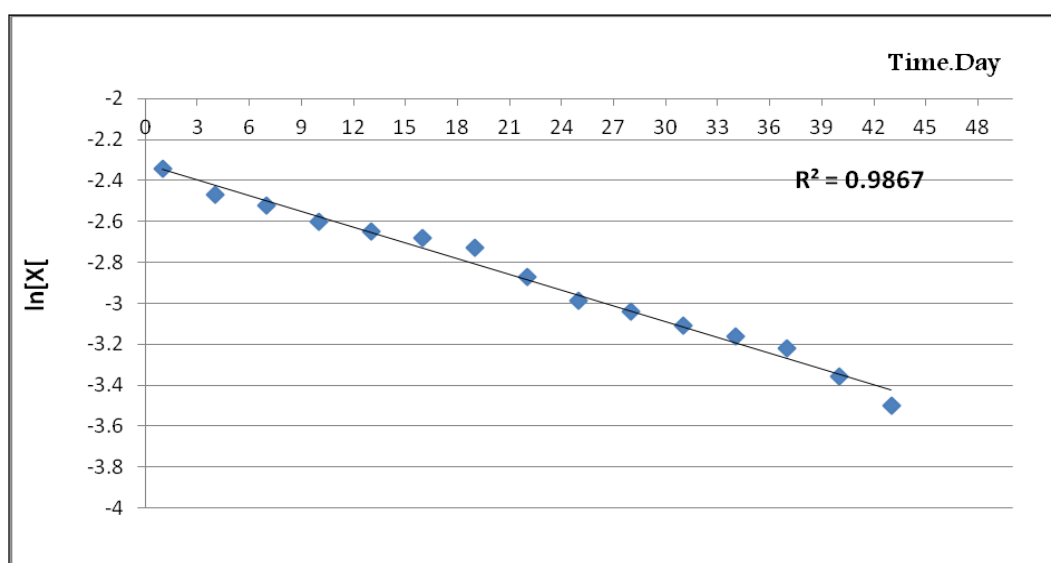
Figure (4.18): ln [A] versus time for polluted water flowed from amoxicillin (one-year).
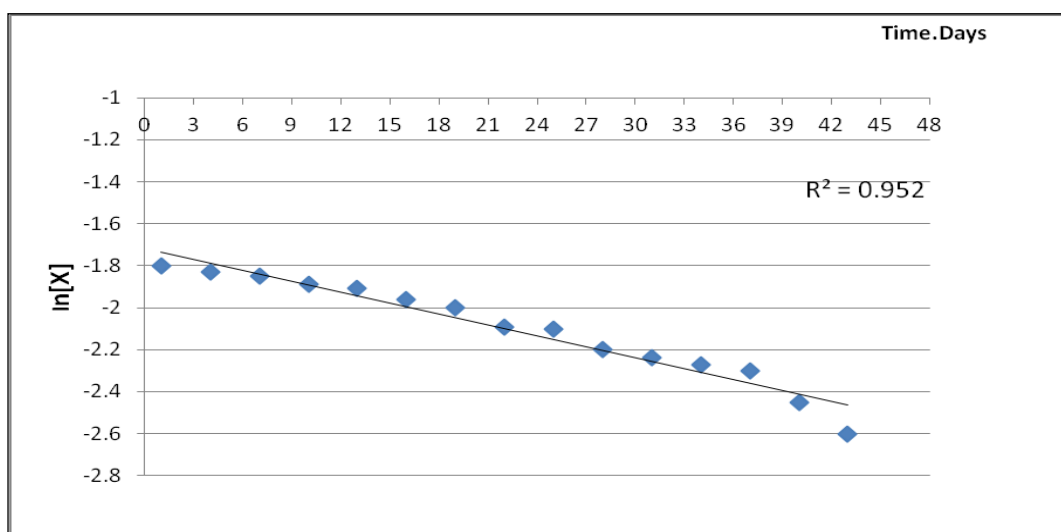
Figure (4.19): ln [A] versus time for polluted water flowed from amoxicillin (15-year).

Table (4.25): Measured concentrations of polluted water flowed from ibuprofen versus time.

| Time	One- year		15-year	
Days	[A] ppm	ln[A]	[A] ppm	Ln[A]
1	$19.93*10^{-3}$	-3.90	$25.83*10^{-3}$	-3.660
4	$19.43*10^{-3}$	-3.94	$24.24*10^{-3}$	-3.720
7	$19.07*10^{-3}$	-3.96	$23.66*10^{-3}$	-3.787
10	$18.75*10^{-3}$	-3.98	$22.54*10^{-3}$	-3.790
13	$18.37*10^{-3}$	-4.00	$22.49*10^{-3}$	-3.795
16	$17.70*10^{-3}$	-4.03	$22.02*10^{-3}$	-3.815
19	$17.48*10^{-3}$	-4.05	$21.34*10^{-3}$	-3.850
22	$17.22*10^{-3}$	-4.06	$21.28*10^{-3}$	-3.850
25	$17.04*10^{-3}$	-4.07	$21.10*10^{-3}$	-3.860
28	$16.94*10^{-3}$	-4.08	$20.55*10^{-3}$	-3.888
31	$16.78*10^{-3}$	-4.10	$20.12*10^{-3}$	-3.900
34	$16.36*10^{-3}$	-4.11	$19.94*10^{-3}$	-3.920
37	$15.72*10^{-3}$	-4.15	$19.08*10^{-3}$	-3.960
40	$15.14*10^{-3}$	-4.19	$18.66*10^{-3}$	-3.980
43	$14.87*10^{-3}$	-4.21	$16.668*10^{-3}$	-4.090
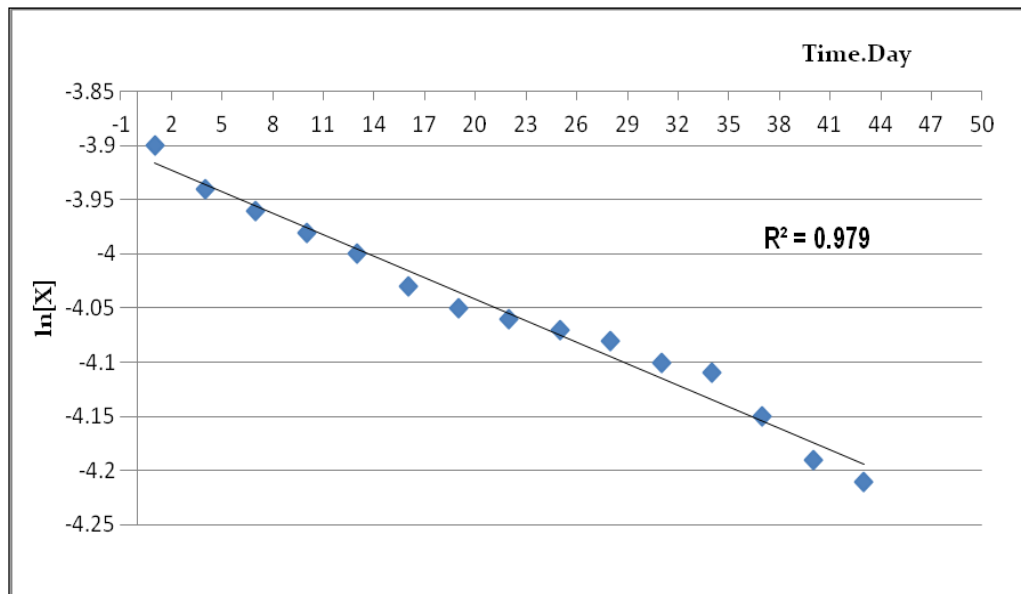
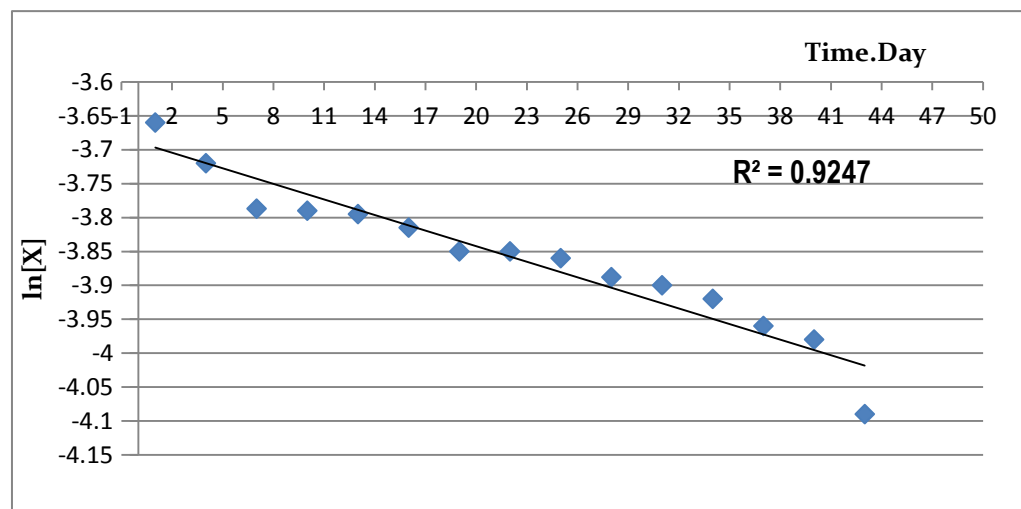**Figure (4. 20):** ln [A] versus time for polluted water flowed from ibuprofen (one-year).

Figure (4. 21): ln [A] versus time for polluted water flowed from ibuprofen (15-year).

Table (4.26): Measured concentrations of polluted water flowed from caffeine versus time.

Time	0ne- year		15-year	
Days	[A] ppm	ln[A]	[A] ppm	ln[A]
1	$18.45*10^{-2}$	-1.69	$38.17*10^{-2}$	-0.960
4	$17.91*10^{-2}$	-1.72	$38.69*10^{-2}$	-0.950
7	$17.10*10^{-2}$	-1.77	$37.18*10^{-2}$	-0.990
10	$16.83*10^{-2}$	-1.78	$36.87*10^{-2}$	-0.998
13	$16.36*10^{-2}$	-1.81	$36.21*10^{-2}$	-1.020
16	$15.68*10^{-2}$	-1.85	$35.19*10^{-2}$	-1.044
19	$15.23*10^{-2}$	-1.88	$34.83*10^{-2}$	-1.055
22	$14.79*10^{-2}$	-1.91	$34.29*10^{-2}$	-1.070
25	$14.37*10^{-2}$	-1.94	$33.93*10^{-2}$	-1.080
28	$13.89*10^{-2}$	-1.97	$33.48*10^{-2}$	-1.094
31	$13.30*10^{-2}$	-2.00	$33.1*10^{-2}$	-1.110
34	$12.67*10^{-2}$	-2.06	$32.44*10^{-2}$	-1.130
37	$12.29*10^{-2}$	-2.10	$31.92*10^{-2}$	-1.150
40	$11.95*10^{-2}$	-2.12	$31.44*10^{-2}$	-1.160
43	$10.72*10^{-2}$	-2.23	$30.95*10^{-2}$	-1.173
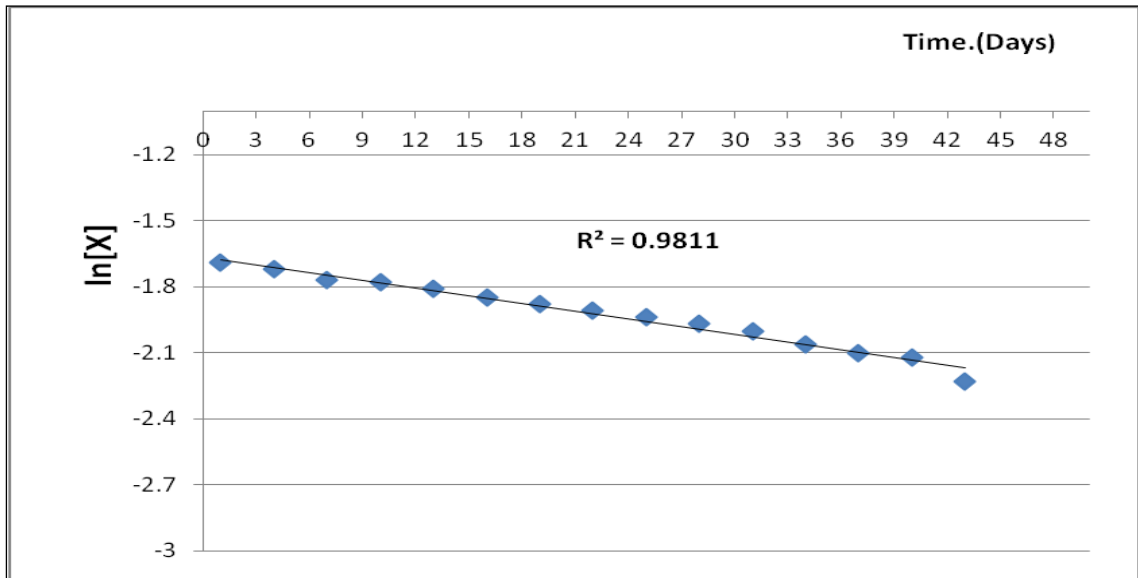
Figure (4.22): ln [A] versus time for polluted water flowed from caffeine (one-year).

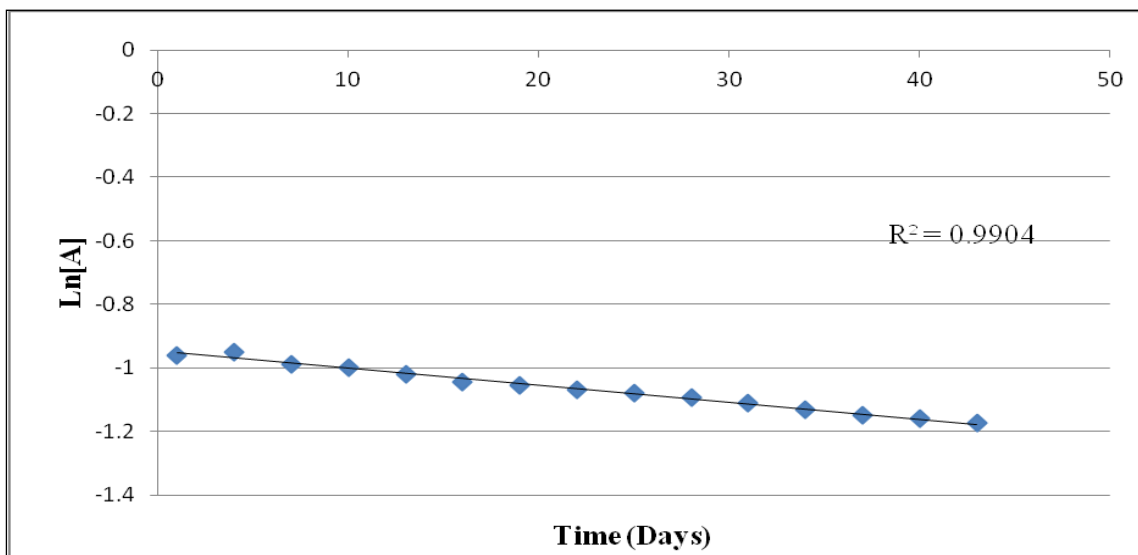**Figure (4.23):** ln [A] versus time for polluted water flowed from caffeine (15-year).

From the results that have obtained, the speed of flow of water in blank columns is much higher than other columns with added medications because of the lack soil correlation with any other additives.

Hydrolysis of ibuprofen, amoxicillin, and caffeine in polluted water followed first order kinetic as prescribed in the plotted graphs straight lines were obtained after plotting ln[A] vs time, **(Dwivedia,A., et.al, 2011)**; **(Tang, K., et al., 20011); (Navarro, P.G., et al, 1998)**; Baek, M., et al, 2010).

As prescribed in the table (4.25), the concentration measured of ibuprofen in polluted water was decreased among the one year and 15-years columns, due to the limited mobility of the compound and rapid degradation, and because the soil used in the experiment have pH 7.41, ibuprofen more dissolving in acidic condition**, (Dwivedia, A., et al, 2011).**

It was noted that amoxicillin concentrations less dramatically and rapidly than ibuprofen due to its nature, as it decomposes during the first 6 hours of time, **(Le Le-Minh, N., et al, 2010).** While it was observed that the concentrations of caffeine were obviously larger than that in both ibuprofen and amoxicillin, this is because caffeine is more water soluble compound. **(Lim, L., and Go, M., 2000).**

Soil Column	Soil Depth	One- year Concentration ppm	15- One- year Concentration ppm

Blank	0-25 cm	Non	Non
	25-50 cm	Non	Non
	50-75 cm	Non	Non
	75-100 cm	Non	Non
	100-125cm	Non	Non
	125-150cm	Non	Non
	150-175cm	Non	Non
	175-200cm	Non	Non
Amoxicillin	0-25 cm	$9.87*10^{-2}$	$18.4*10^{-2}$
	25-50 cm	$6.02*10^{-2}$	$15.2*10^{-2}$
	50-75 cm	$6.03*10^{-3}$	$13.65*10^{-2}$
	75-100 cm	$4.43*10^{-3}$	$10.63*10^{-2}$
	100-125cm	$3.36*10^{-3}$	$9.44*10^{-2}$
	125-150cm	$2.20*10^{-3}$	$3.98*10^{-2}$
	150-175cm	$1.80*10^{-3}$	$0.95*10^{-2}$
	175-200cm	$1.06*10^{-4}$	$0.03*10^{-3}$

Table (4.27): Represents concentrations of amoxicillin in different soil depths
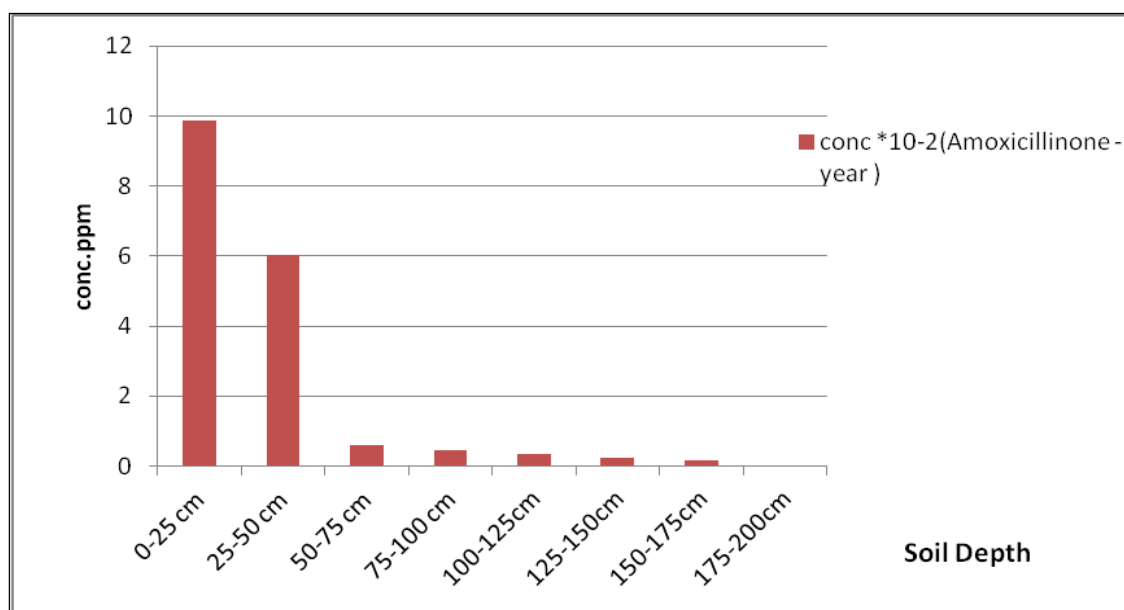
Figure (4.24): Amoxicillin concentrations measured in soil layers for one year
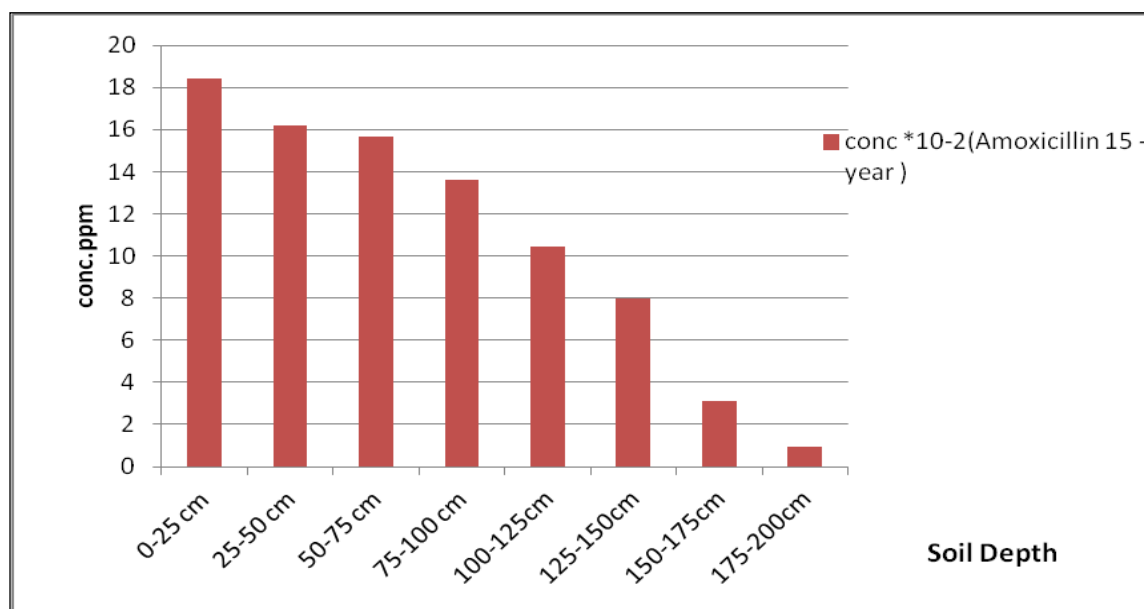
Figure (4.25): Amoxicillin concentrations measured in soil layers for 15 years.

Table (4.28): Represents concentrations of ibuprofen in different soil depths

Soil Column	Soil Depth	One- year Concentration ppm	15 - One- year Concentration ppm
Blank	0-25 cm	Non	Non
	25-50 cm	Non	Non
	50-75 cm	Non	Non
	75-100 cm	Non	Non
	100-125cm	Non	Non
	125-150cm	Non	Non
	150-175cm	Non	Non
	175-200cm	Non	Non
Ibuprofen	0-25 cm	$23.25*10^{-2}$	$36.54*10^{-2}$
	25-50 cm	$18.05*10^{-2}$	$34.12*10^{-2}$
	50-75 cm	$14.35*10^{-2}$	$29.23*10^{-2}$
	75-100 cm	$11.36*10^{-2}$	$23.56*10^{-2}$
	100-125cm	$9.50*10^{-2}$	$19.20*10^{-2}$
	125-150cm	$6.44*10^{-2}$	$15.33*10^{-2}$
	150-175cm	$2.98*10^{-2}$	$11.54*10^{-2}$
	175-200cm	$1.25*10^{-2}$	$9.57*10^{-2}$

Figure (4.26): Ibuprofen concentrations measured in soil layers for one-year.
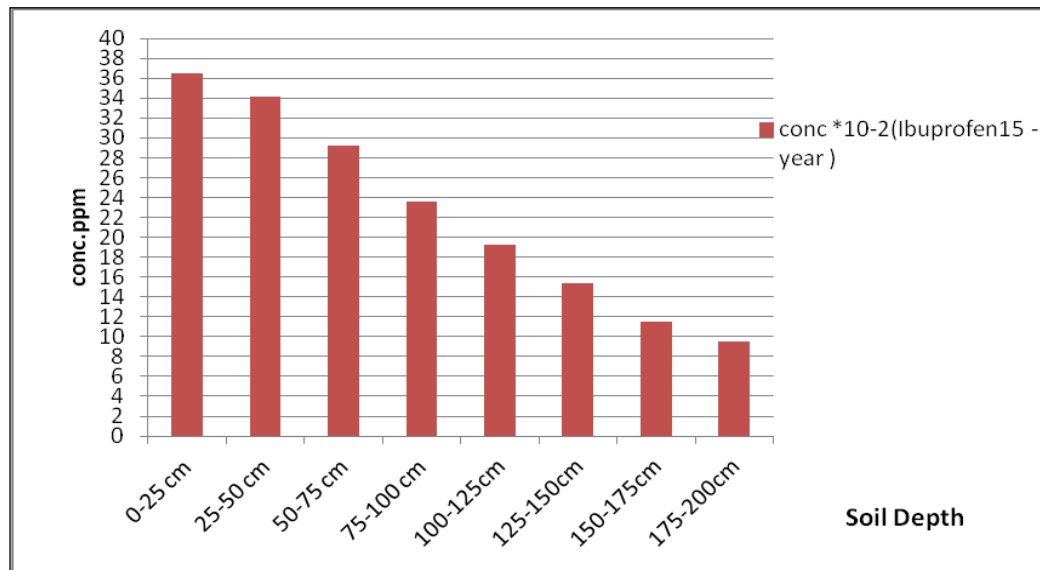
Figure (4.27): Ibuprofen concentrations measured in soil layers for 15 -years.

Table (4.29): Represents concentrations of caffeine in different soil depths.

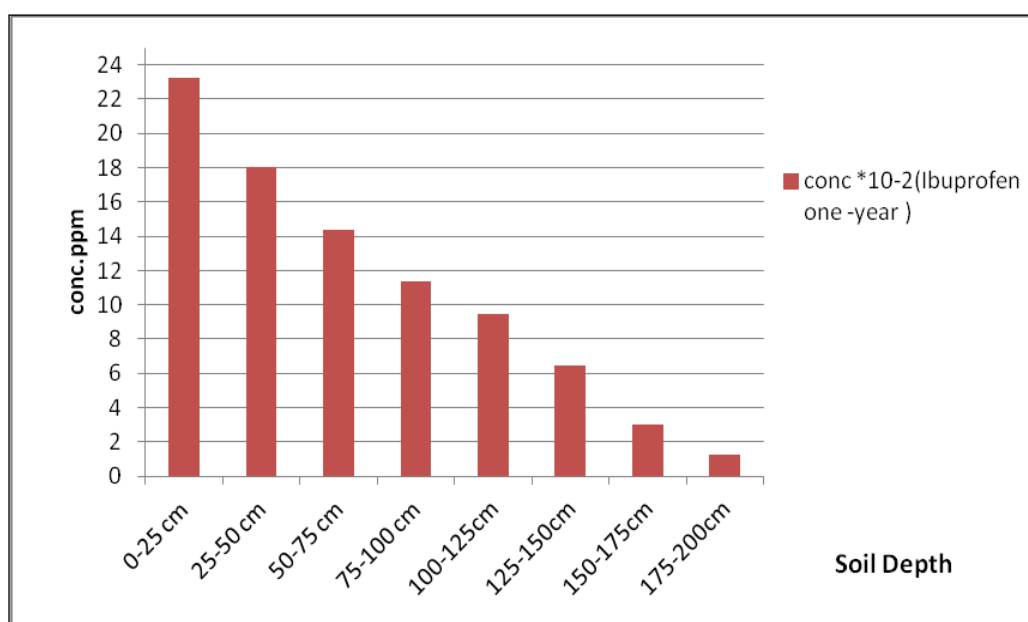| Soil Column	Soil Depth	One- year Concentration ppm	15- One- year Concentration ppm
Blank	0-25 cm	Non	Non
	25-50 cm	Non	Non
	50-75 cm	Non	Non
	75-100 cm	Non	Non
	100-125cm	Non	Non
	125-150cm	Non	Non
	150-175cm	Non	Non
	175-200cm	Non	Non
Caffeine	0-25 cm	$6.98*10^{-2}$	$19.36*10^{-2}$
	25-50 cm	$8.34*10^{-2}$	$21.74*10^{-2}$
	50-75 cm	$9.69*10^{-2}$	$23.89*10^{-2}$
	75-100 cm	$11.55*10^{-2}$	$25.55*10^{-2}$
	100-125cm	$12.17*10^{-2}$	$26.17*10^{-2}$
	125-150cm	$12.74*10^{-2}$	$29.24*10^{-2}$
	150-175cm	$13.86*10^{-2}$	$32.86*10^{-2}$
	175-200cm	$14.23*10^{-2}$	$37.23*10^{-2}$
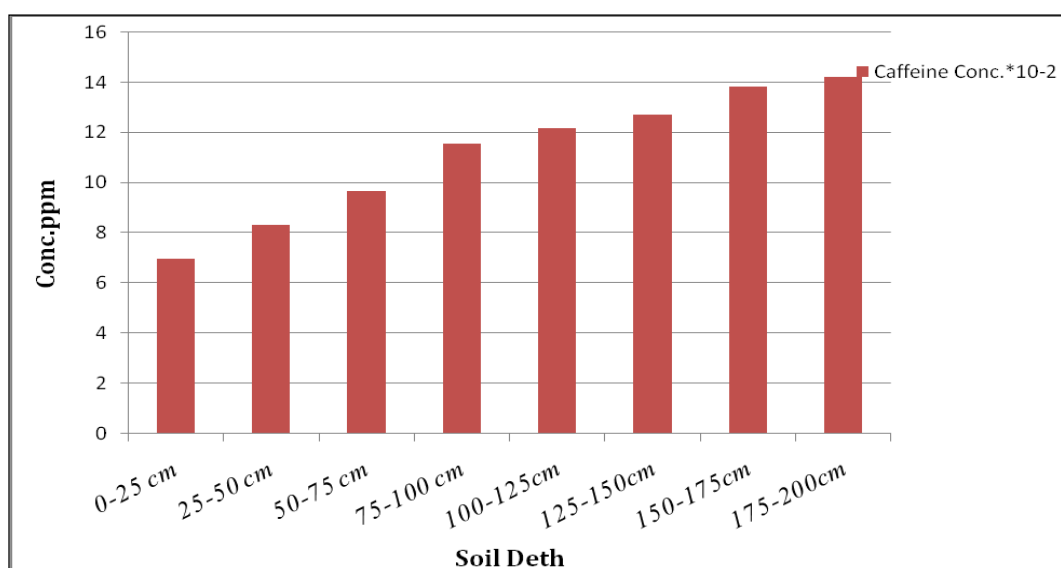
Figure (4.28): Caffeine concentrations measured in soil layers for one year.
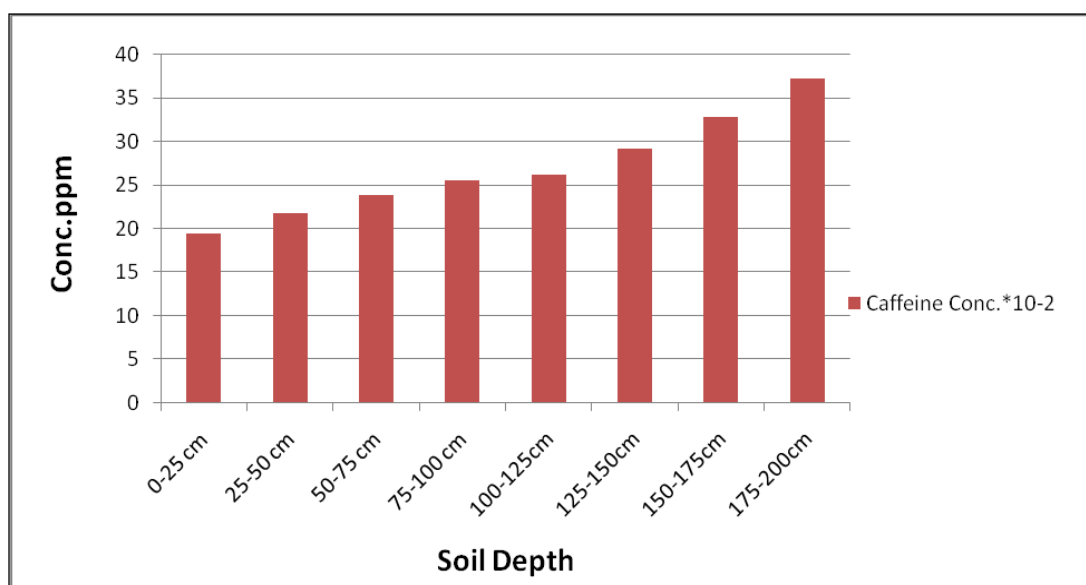
Figure (4.29): Caffeine concentrations measured in soil layers for 15- years.
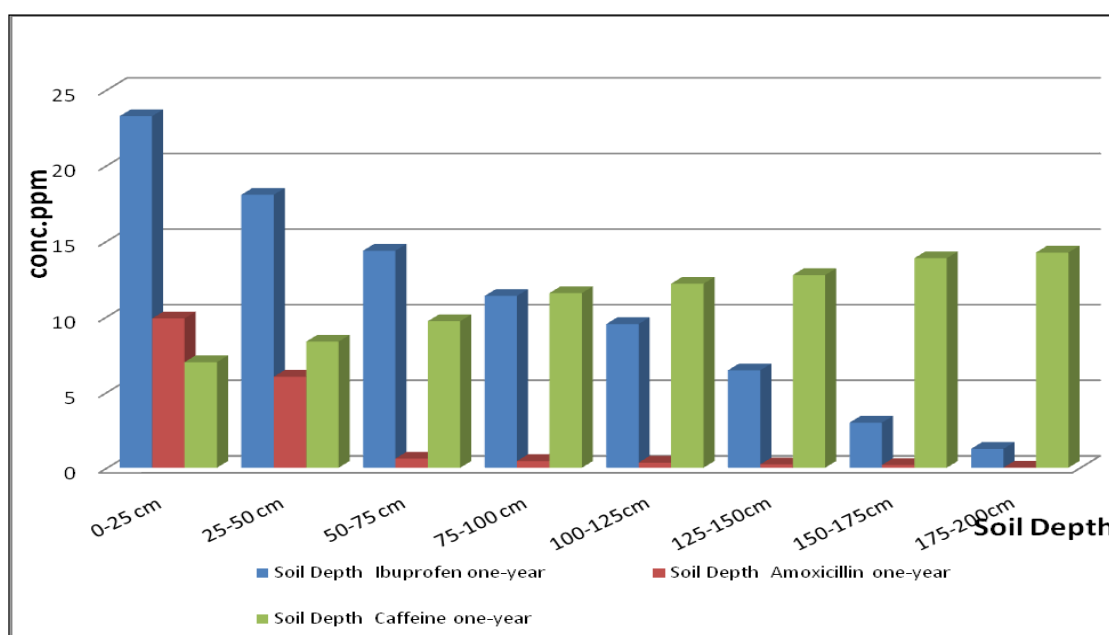
Figure (4.30): Amoxicillin, ibuprofen, and caffeine concentrations measured in soil layers for one year.
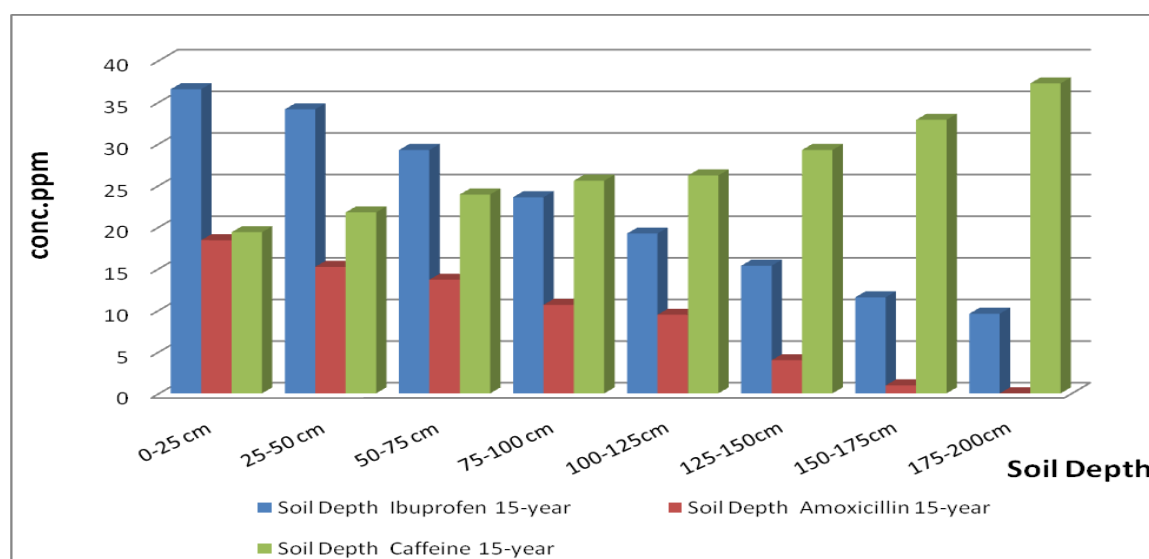
Figure (4.31): Amoxicillin, ibuprofen, and caffeine concentrations measured in soil layers for 15years.

From the results of this part of research the pharmaceuticals were distributed along the columns, amoxicillin in one and fifteen years soil columns, its higher concentrations were found in area 0-25 cm, and the amount of amoxicillin was rapidly decreased as increasing in soil depth

which was an indication of amoxicillin low mobility in soil due to its rapid degradation**, (Le-Minh et.al, 2010).**

In Ibuprofen one year and fifteen years soil columns highest concentrations were obtained in area 0-25 cm, 25-50cm, because it has both hydrophilic and hydrophobic feature so it can dissolve in water and adsorb on soil in the same time.

In Caffeine one and fifteen years columns, especially in areas from 150-175 cm and 175-200 cm, indicating a higher mobility of caffeine than ibuprofen &amoxicillin in soil, on the other hand, caffeine has higher solubility in water, **(Lim, L .,and Go, M., 2000).**

4.7. Mass Balance

The purpose from this possess is accounting for pharmaceuticals entering and leaving a system, mathematically the mass balance for a system without a chemical reaction is as follows:

Input= Output + Accumulation

In our study we have the following equation:

Input =Output (conc. in leachate) + (conc. adsorbed on soil) + decomposed materials

The input of each drug per day was 50 ppm, and the total input for each drug in 43 days was 2150 ppm. The following table shows the mass balance for the pharmaceuticals drugs that we used in our study.

Table (4.30): Mass balance for amoxicillin, ibuprofen and caffeine.

In put ppm/43 days	Out put		
	Total conc. in leachate (ppm)/43days	Total conc. adsorbed on soil(ppm)/43days	Decomposed (%)
Amoxicillin One-year			
2150	0.94	0.23	0.21
Amoxicillin 15-year			
32,250 (3.23%)	28.22	16.44	~ 3.20
Ibuprofen One-year			
2150	0.26	0.80	0.21
Ibuprofen 15-year			
32,250 (3.23%)	6.00	27.00	~ 3.20
Caffeine one year			
2150	2.25	0.90	0.21
Caffeine 15-year			
32,250 (3.23%)	70.00	32.55	~3.20

In general it was noticed from calculation the mass balance for the three pharmaceuticals , table (4.30),that the output was not equal the input, because they decomposed and degraded into several compound , due to their influence by several factors like temperature, pH, soil structure and the nature of the drugs itself.

For amoxicillin its output was not equal input because it's very degradable compound and affects with biological and non biological factors in soil and wastewater especially ammonia, phosphate and hydroxyl group. All these factor can participate in the reduction of amoxicillin level. Again in the case of ibuprofen its output is not equal the input because it can decompose thermally for many toxic product that result from ibuprofen degradation like, 4-isobutlacetophenone, and it is a popular non-prescription drugs that may entail prolong use ,it's necessary to monitor the presence of all degradation products and to study their long term toxicity, **(Caviglioli, G., et al .,2002)** .

For caffeine its output is very small compared with its input because it degrades within few weeks and produce theobromine and theophylline compound which are useful in industrial world**,(Jacobs,E .L .,et al., 2012); (Sathyanarayana ,N., et al ., 2012).**

According to the table (4.13), we observed that when we added 50 ppm, the leachate shown on the tables gave us straight mass balance. In table (4.30) we couldn't find the same behavior due to the first the life time of

those pharmaceuticals are less than 5 hours. Secondly, whatever we got without degradation has been diluted due to daily addition of amoxicillin, ibuprofen and caffeine , in addition to the bacterial effect , and that why we got very small concentration less than 1ppm(**Kakimoto,T., and Funamiz.N., (2007).**

Conclusion and Recommendation

Conclusions

Detection of numerous pharmaceuticals and personal care products (PPCPs) in the environment has gained a public attention due to their known and/or potential adverse impacts on ecological and public health. Previous studies consistently demonstrate the prevalence of pharmaceuticals in the environment but we do not yet know how concentrations vary over time within a given system.

The adsorption characteristics of Pharmaceuticals in soils and ground water is of great importance environmentally, because such process is associated with the ecotoxicity, degradation, transportation, and bioaccumulation of them in the soil environment. Adsorption of ibuprofen, amoxicillin, and caffeine was studied and the following results were obtained:

1. Amoxicillin and ibuprofen soil adsorption in this study was increased with increasing temperature versus time.

2. The study showed that caffeine soil -adsorption is lower than that in ibuprofen and amoxicillin with increasing temperature, due to its high water solubility.

3. Ibuprofen hydrolysis efficiency was more efficient under acidic at pH (1.5and 4) condition than that in neutral or alkaline, and its maximum adsorption was observed in the pH range of (7-12).

4. Significant concentration of caffeine in supernatant was at pH 1.5, then 4, and decreased at 12 pH, with more soil adsorption at alkaline conditions pH ⟩7.

5. The more amoxicillin hydrolysis was at pH 4-7, with highly adsorption at pH 1.5 and 12.

6. The kinetics and equilibrium of adsorption of ibuprofen, amoxicillin and caffeine were best described using first-order reaction and Freundlich isotherm.

7. Ibuprofen concentration was decreased in leachates among the one year and 15-years columns, it can be expected that the soil passage mean an effective barrier for ibuprofen, due to sorption and/or by microbial degradation and have a limited mobility.

8. Amoxicillin concentrations decreased dramatically and rapidly in leachate among the one year and15-years columns, than ibuprofen due to its nature highly degradable compound .

9. It was observed that the concentrations of caffeine were obviously larger than that in ibuprofen and amoxicillin among the one year and 15-

years columns, this is because that caffeine is more water soluble, despite it didn't reach 1ppm.

10.   During the columns study the leachate from those columns found less than 1ppm and this mean that there will be no environmental effects of those pharmaceuticals on the ground water.

Recommendations

To reduce the pharmaceutical environmental pollution, it is recommended to:

1. Getting back to alternative medicine and using herbal medications to minimize pharmaceutical pollution, and if they end up to soil or water systems, causing exposure to organisms that have been adapted to these products.

2. Tighten controls on pharmacies and prevent them from selling medicines indiscriminately and without a prescription approved

3. Concerned ministries should agree on a clear specification of responsibilities towards pharmaceuticals waste management in Palestine.

4. More laws and regulations related to pharmaceuticals waste management outside health care institutions should be applied.

5. Waste from treated animals should be stored in a warm moist place for long as possible before spreading it into fields. This gives the beneficial soil microbes an opportunity to act on an antibiotic, before it has the chance to leach into soils and waterways

6. More researches in this regard should be carried out, further investigation into the fate of ibuprofen, amoxicillin, caffeine in the environment.

A. Degradation rates, local and global distribution, bioavailability of ibuprofen, amoxicillin, and caffeine.

B. Further improvement and validation of the employed methods for the analysis of these pharmaceuticals in soil, water and liquid manure.

D. Find healthy scientific methods for safe disposal of expired medicines and how to increase the wastewater treatment plants efficiency in Palestine.

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كلية الدراسات العليا

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الملخص

أثار اهتمام المجتمع في الاونة الاخيرة وجود الملوثات الدوائية في المياه لما لها من تأثير على البيئة خصوصا على الحياة المائية والتربة والمياه الجوفية ، والتي ربما تؤثر على النظام البيئي بشكل عام ، ليمتد تأثيرها ويصل إلى النباتات والحيوانات والإنسان– مما استدعى في الآونة الأخيرة إجراء دراسات تجريبية وأبحاث رائدة تتعلق بموضوع هذه الملوثات .

في هذه الدراسة تم اختيار ثلاثة أنواع من الأدوية ، وهي الأموكسيسيلين ، الإيبوبروفين والكافئين كأمثلة على المستحضرات الصيدلانية التي يتم تداولها و تسويقها في الأراضي الفلسطينية سواء في الصيدليات ، العيادات الخاصة، المستشفيات أو كعلاجات بيطرية. وفي هذا البحث تم دراسة السلوك الإدمصاصي لهذه الأدوية في التربة ، تأثير كل من درجة الحرارة ودرجة الحموضة في عملية الادمصاص، وبالإضافة إلى ذلك إمكانية وصولها للمياه الجوفية، وتمت جميع هذه الدراسات باستخدام جهاز الامتصاص الطيفي للأشعة فوق البنفسجية والضوء المرئي UV–Vis spectrophotometer.

أظهرت نتائج هذه الدراسة أن عملية ادمصاص هذه الأدوية على التربة يتبع نظام "Freundlich" ، كما كشفت الدراسة أيضا أن تركيز الكافيين في الماء الراشح من التربة أعلى منه في كل من تركيز الايبوبروفين والأموكسيسيلين، وذلك بسبب ذائبية مادة الكافيين العالية في الماء إلا انه لم يتعدى أل "1"ppm ، كما لوحظ أن الايبوبروفين والاموكسيسيلين يمكن أن يتواجد على التربة، وفي المياه الجوفية وبتراكيز قليلة جدا ، ولهذا حصلنا على تراكيز اقل من

1ppmمما يدل على أن هذه الأدوية تحولت إلى مركبات أخرى مع مرور الوقت تكون ضارة بالبيئة و بصحة الإنسان، لذا يستوجب إجراء دراسات إضافية أخرى   لهذه لمثل هذه الادوية ومعرفة مدى خطورتها على صحة الإنسان.