Assessment of Commonly Used Pesticides in the Ground Water of the Shallow Aquifer Systems in Jericho and Jeftlik areas/ Lower Jordan Valley, Occupied Palestinian Territories

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***Abstract*— *One of the most important pollutants that may reach the groundwater through agricultural return flow combined with abuse and ignorance is pesticides. This study focuses on the examination of the concentration of three pesticides: Abamectin, Imidacloprid, and ß-Cyfluthrin, all of which have been used in large quantities in the Lower Jordan Valley (LJV) for the last three decades. Twenty five groundwater samples were collected from water boreholes where water is abstracted from two phreatic aquifer systems which are the Plio-Plistocene aquifer system in Jericho and Lower Al Jeftlik areas and the Eocene carbonate aquifer system in the Middle of Al Jeftlik. The depth of the boreholes in both aquifer system ranges between 80 and 120 m. Water samples were analyzed for Abamectin, Imidacloprid, and ß-Cyfluthrin using the HPLC-UV method. These samples represent two main agricultural locations (Jericho, and the Al Jeftlik). Of the 25 wells sampled, Abamectin was detected in 11 wells in concentrations ranging between 1.24 ppb and 81.71ppb. Imidacloprid was detected in 24 wells in concentrations ranging between 1.60ppb and 325.0ppb. Finally, ß-Cyfluthrin was detected in 7 wells in concentrations ranging between 1.10 and 24.46ppb.*

Aquifer lithology, groundwater flow directions, type of agricultural activity are major factors in controlling pesticide concentrations in groundwater. The highest values were measured where the aquifer consists of gravel and sand sediments, combined with intensive agricultural activities, followed by sand-silt aquifer. The lowest concentrations were found in boreholes where carbonate aquifer is the main source of water which indicates that other source of water flow into the system. The results of this study demonstrate that these pesticides are used heavily and in an improper way in the lower Jordan Valley, increasing the risk of adverse environmental and public health effects. Much attention should be given to addressing the potential problem of environmental and groundwater contamination by these pesticides.

***Keywords*— Shallow Aquifer, Jericho area, Pesticide, Abamectin, Imidacloprid, ß-Cyfluthrin, Jericho.**

I. INTRODUCTION

Pesticide usage is one of the major fundamental problems that threaten groundwater quality in many areas of the West Bank the degree of risk depends on the amount of pesticides added to the field, the physical properties of the unsaturated zone, and the environmental classification of the chemicals as a function of the duration of time in the environment.

Jericho District locates in the Lower Jordan Valley area and consider as the food basket for the West Bank. The climate of the area is hot and dry during summer and mild in winter. The annual rainfall average is about 300 mm in Jeftlik area in the north and decrease southwards to about 200 mm in Jericho [1]. Due to high evaporation rates, agricultural activities without irrigation practices are impossible. Sources of water in the two locations is limited to groundwater wells taping water from the Shallow aquifer system of Plio-Plistocene ages, that consists of alluvial sediment overlaying carbonate rock of Eocene age.

The aquifer systems have different water shed, in Jericho area groundwater flow from the carbonate Mountain aquifer east wards crossing the fault system into the Plio-Plistocene aquifer system [2], where in Al Jeftlik area groundwater infiltrated from the surface during flooding period as well as from agricultural return flow, and laterally from west to east parallel with the Graben axis. The alluvial, gravel, sand sediments is overlaying the limestone layers of Eocene age where both formation consider as one aquifer system. In both areas direct recharge from rainfall is limited [3-4] and agricultural return flow can influence the quality of groundwater.

Analysis of groundwater samples indicate that agricultural contaminants come from three main agricultural ingredients; these are: 1) bromide, which is injected as a fumigant onto the land in the form of a methyl bromide gas; 2) nitrogen fertilizers, pesticides, and animal manure; 3) and nitrate, chloride, magnesium, and lithium compounds which might appear in surplus amounts due to irrigation back flow and infiltration of the groundwater with soil [5]. The cultivated areas in the Jericho District including two locations is about 2,419.4 hectares and the amount of pesticides used is about 82 tons per year [6].

Pesticide usage raises a number of environmental concerns. Each use of a pesticide carries some associated risks, but proper pesticide usage decreases these risks. The presence of pesticides in groundwater, even in low concentrations, is enough to cause a variety of adverse health effects, such as causing cancer and reproductive success [7] [8] [9][7-8].The acceptable limit for a pesticide in groundwater is 0.1 ppb and 0.5 ppb for multiple pesticides [10] [11]. Pesticide contamination of groundwater is a subject of national importance. This especially concerns people living in the agricultural areas where pesticides are most often used, as about 95 percent of that population relies on groundwater for drinking water. The misuse of pesticides had increased in occurrence in groundwater in the northern part of the West Bank and in the Gaza Strip[12]. Using water contaminated with pesticides for drinking purposes has a potentially high health risk [13] .

Abamectin, Imidacloprid, and ß-Cyfluthrin have been used in large quantities in the Lower Jordan Valley. Imidacloprid acts as a neurotoxin and is considered a potential groundwater contaminant [14-15].The pesticide Abamectin has adverse effects on the aquatic environment (daphnia and fish) [14] [15,16] and has the potential to cause hepatotoxicity [5]. ß-Cyfluthrin is a potent neurotic and can cause significant weight reduction [6-7].Therefore, the heavy use of these pesticides could cause high environmental and health risks. The main objective of this study is to investigate the concentration of these three majorly used pesticides (Abamectin, Imidacloprid, and ß-Cyfluthrin) in the groundwater of the Shallow aquifer system in Jericho and Jeftlik areas. The results of this study will be used in risk characterization of pesticides in drinking and groundwater in the Jericho District.

II. MATERIAL AND METHOD

2.1 Study Area

The fertile soil, availability of groundwater about 40 MCM/year in form of spring water and boreholes, in addition to the suitable climate during winter season make the Jordan Valley focus for intensive agriculture practices. The study area provides about 80% of the West Bank market's agricultural vegetable demand during winter season[17]. Yet improper agricultural practices could be a source of contamination to groundwater. Due to the low cost of water, over-irrigation is widely spread in the study locations. It is estimated that about 40% of the currently irrigated water volume could be saved by applying precision irrigation [18]. Moreover, farmers use pesticides such as Abamectin, Imidacloprid, and ß-Cyfluthrin for crop protection, but unfortunately, this usage is not optimized. These practices increase the agricultural return flow to the groundwater body [19].

2.2 Sampling

Twenty five groundwater samples were collected randomly from groundwater boreholes (Figure 1). Samples were collected during March 2010, after the end of the rainy season. Water sample collected after 20 minutes pumping prior to sample collection. Container with five liters volume were used in collection of water samples and preserved with phosphoric acid (85%). The samples were then wrapped in aluminum foil is used to protect the sample, placed in ice containers, and transported to the lab where they were placed in refrigerators at 4°C until analysis. Analysis of the collected samples was conducted within one week of the sample collection. The analysis method follows USEPA- method (1985). "Liquid -liquid extraction of trace level pesticides in Process stream EPA" 600/S2-84-195 [20].

2.3 Samples extraction and analysis

The collected samples were extracted using liquid-liquid extraction and analyzed for the three pesticides (Abamectin, Imidacloprid, and ß-Cyfluthrin) using the HPLC-UV method [21-22].

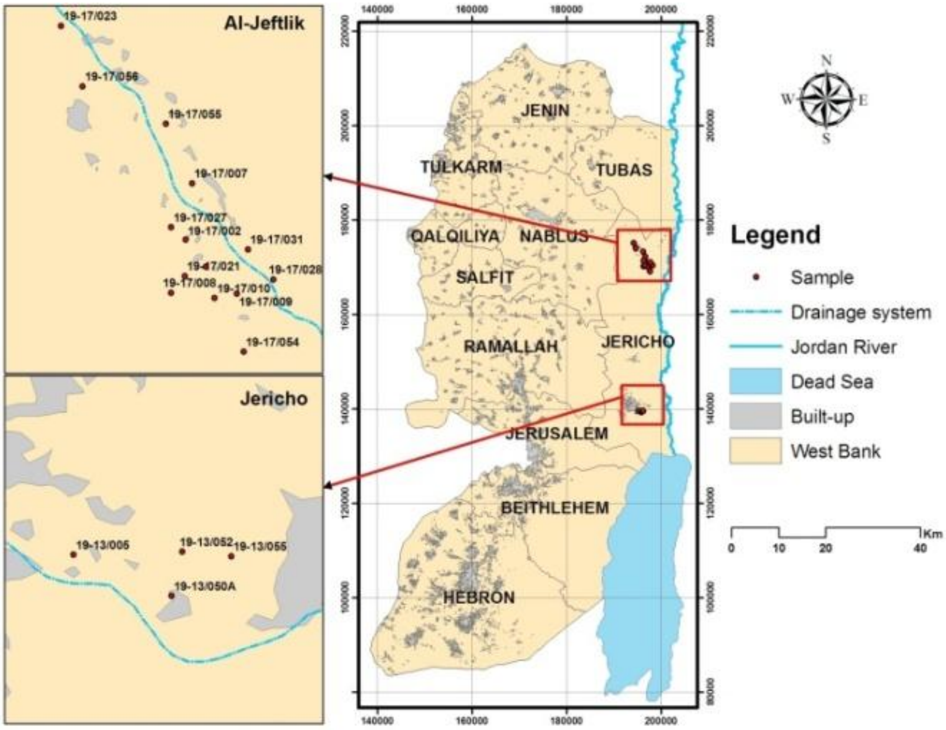

FIG. 1: LOCATIONS OF SAMPLING SITES IN JERICHO AND AL-JEFTLIK, LOWER JORDAN VALLEY

III. RESULTS AND DISCUSSION

In this study, attempts were made to trace the effects of using pesticides in unaccountable amounts through the examination of the concentrations of three pesticides (Abamectin, Imidacloprid, and ß-Cyfluthrin) which are used commonly in large quantities in the study area. All the 25 groundwater samples in the study area contained detectable amounts of one or more of the three pesticides analyzed. The most abundant concentration was that of Imidacloprid (Table 1).Twenty four samples out of 25 showed detectable levels of Imidacloprid, while11 samples showed detectable levels of Abamectin and only 7 samples showed detectable levels of β-Cyfluthrin. Imidacloprid was not only found in the largest number of samples (24/25samples), but also with the highest concentrations ranging between 1.60 ppb and 325.00 ppb compared to Abamectin with concentrations ranging between 1.24 ppb and 81.71 ppb and β-Cyfluthrin with concentrations ranging between1.10 ppb and 24.46 ppb. The total concentration of the three pesticides was found to be in the range of 4.72-341.36 ppb. Previous studies indicate that pesticide concentrations in groundwater in the West Bank and Gaza were higher than the acceptable limit for individual or the total pesticides. Ghanem et al., (2011) investigated the quantitative effect of pesticides including 2, 4-D dichlorphenoxy acetic acids, Paraquat, Atrazine (2-chloro-4-ethylamino-6-isopropylamino-s-triazine), and MCPP 2-(2-Methyl-4-chlorophenoxy) pro-panioic acid on groundwater quality due to intinsive agricultural activities in Jenin and Tulkarem districts in the northern part of the West Bank [13]. Their results revealed that the majority of the samples taken had concentrations of 10 μg/L, and that using these wells for drinking purposes has a potentially high health risk. In the Gaza Strip, Shomar et al., (2005) conducted a study that revealed that atrazine, atrazine-desisopropyl, propazine, and simazine were detected in 18, 15, 8 and 5 wells with average concentrations of 3.5, 1.2, 1.5 and 2.3μg/L, respectively [12]. The results of this study confirmed previous studies and revealed that pesticides such as Abamectin, Imidacloprid, and ß-Cyfluthrin are used heavily and improperly in the study area.

Moreover, in this study, significant variations in pesticide concentrations were noted amongst different wells varying in depth, composition of aquifer system, locations.

The physical properties of a pesticide play a role in its arrival into groundwater and have often been used to predict the likelihood of its reaching groundwater in detectable concentrations. Hydrophobic pesticides interact strongly with soil compared to hydrophilic (polar) pesticides. The strong interaction of a pesticide with soil decreases the probability of the arrival of that pesticide into the groundwater [21-24]. For the three pesticides investigated in this study, β-Cyfluthrin is the most hydrophobic so its interaction with soil is the highest and the probability of its arrival in the groundwater is the lowest. Therefore its concentration in the groundwater was the lowest. Imidacloprid, on the other hand, is the least hydrophobic (most polar) of the three pesticides and therefore had the highest concentration in the groundwater. Abamectin has intermediate hydrophobicity (between Imidacloprid and β-Cyfluthrin), and therefore its concentration in groundwater is between the concentrations of β-Cyfluthrin and Imidacloprid. The results of this study have confirmed this; groundwater of the study area has high concentrations of Imidacloprid followed by Abamectin and finally β-Cyfluthrin.

TABLE 1
CONCENTRATIONS OF ABAMECTIN, IMIDACLOPRID, AND ß-CYFLUTHRIN IN THE 25 GROUNDWATER SAMPLES (IN PPB), G: GRAVEL, SA: SAND, CA: CARBONATE

Sample #	Abamectin	Imidacloprid	β-Cyfluthrin	Total	Depth in m	Aquifer
1	ND	21.04	ND	21.04	95	Sa,Si
2	ND	16.29	ND	16.29	88	Sa,Si
3	13.82	325.00	2.54	341.36	85	G,Sa,
4	1.24	24.36	ND	25.60	110	G&Ca
5	1.24	17.65	ND	18.89	95	G&Ca
6	ND	18.17	ND	18.17	93	G&Ca
7	ND	16.91	ND	16.91	120	G&Ca
8	ND	16.00	ND	16.00	115	Sa,Si
9	ND	19.20	ND	19.20	128	G&Ca
10	26.48	16.32	ND	42.80	90	G,Sa
11	ND	20.00	7.84	27.84	96	G&Sa&Si
12	1.88	1.60	1.24	4.72	120	G&S
13	ND	25.32	1.10	26.42	96	G&S
14	7.43	15.03	21.68	44.14	110	G,Sa,Si
15	ND	18.15	24.46	42.61	105	G,Sa,Si
16	ND	17.00	ND	17.00	95	Si,
17	ND	16.63	ND	16.63	98	S&Si
18	12.65	ND	ND	12.65	85	S&Si
19	81.71	16.89	ND	98.60	95	Sa,Si
20	ND	16.00	ND	16.00	86	Sa,Cl
21	ND	16.26	ND	16.26	85	Si.Cl
22	1.50	17.86	ND	19.36	88	Si,Cl
23	3.24	17.03	10.00	30.27	88	G,Sa,Si
24	ND	95.12	ND	95.12	100	G,Sa,Si
25	6.04	18.24	ND	24.28	113	Si,Cl

Evidence of agricultural return flow and anthropogenic influence has been reported [3, 11]. Solubility of pesticides in water also plays a role in the arrival of pesticides into groundwater [25]. For example, Imidacloprid, which is polar, has higher solubility compared to the other two pesticides, and in line with the expectation, it has the highest concentration in the groundwater and has also been detected more frequently (in 96% of the samples). A direct correlation between the solubility of the pesticide in water and its concentration in the ground, and between the solubility of the pesticide in water and the number of wells which are contaminated with the pesticide has been found in this study.

The well depth, composition of aquifer system plays the important role in controlling the pesticide concentration in groundwater [23]. However, the dominance of other factors such as the lithology make this role unclear for some wells (Figure 2). Figures 2 and 3 show that water samples related to wells with a depth ranging between 60 m and 100 m, and located in areas where carbonate aquifer is the dominant, contain low pesticide concentrations. On the other hand, with increasing depth between 100 m to 140 m where a contribution of carbonate aquifer increase, the pesticide concentration decreases (R^2=0.62) .

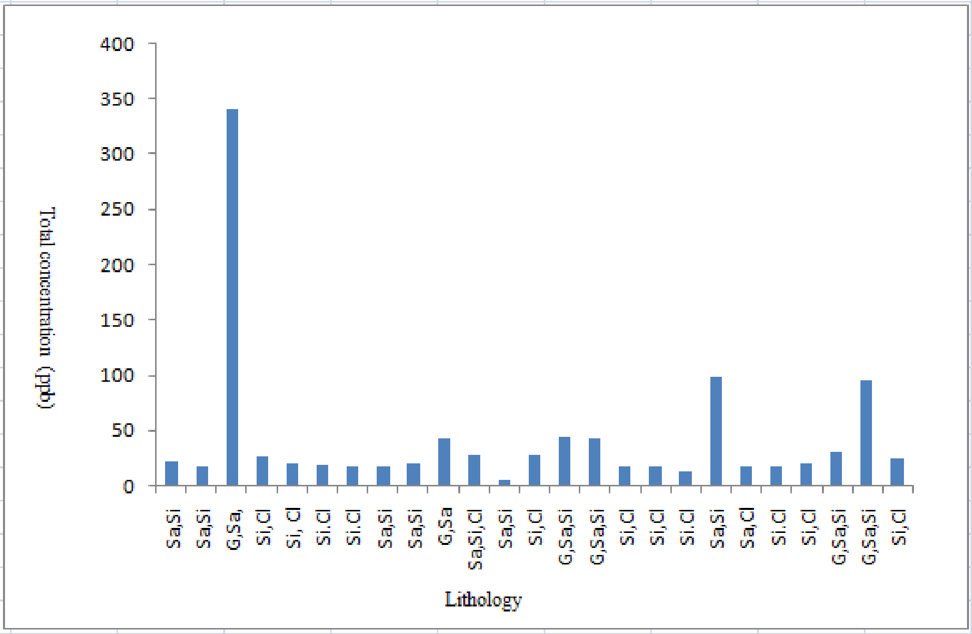

FIG. 2: RELATION BETWEEN TOTAL PESTICIDES CONCENTRATION IN WATER SAMPLES AND LITHOLOGY.

The average permeability of the soil horizon in Jericho and Al Jeftlik areas is about 3.5 *10E-2 m/S. The permeability of Samra formation which form the Plio-Plistocene aquifer system is about 3*10E-3 m/S [27].

Table 1 and Figure 3 show that the total concentration of pesticides in ground water depends on the lithology of overlaying layers as well as on the recharge areas (need to add figures). Gravel, sand and silt layers allow pesticides to infiltrate down to the aquifer system, while carbonate layers of Eocene age receive water from unpolluted Mountain Aquifer. Thus, the highest concentration of pesticides was found in boreholes with gravel and sand sediments, while low concentrations were found in boreholes with carbonate sediments.

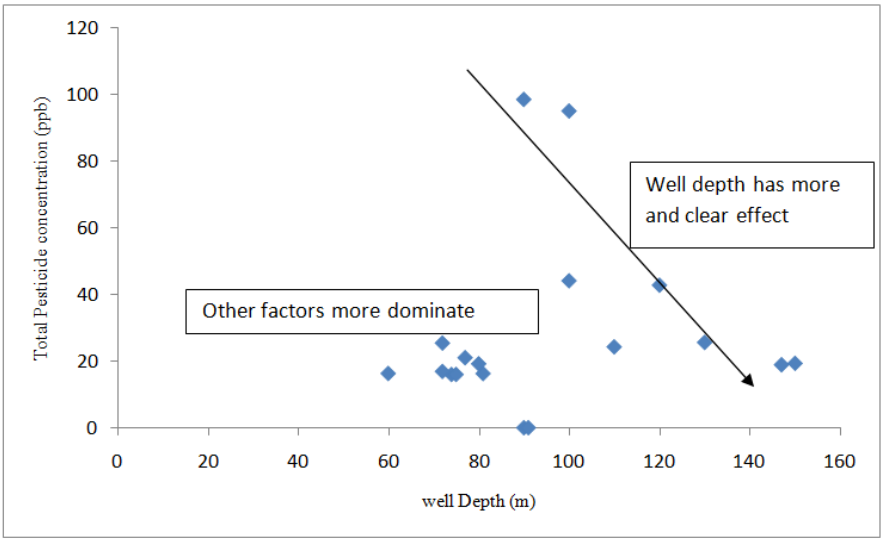

FIG. 3: RELATION BETWEEN TOTAL PESTICIDE CONCENTRATION IN WATER SAMPLES AND WELL DEPTH.

IV. CONCLUSION

Groundwater from the shallow aquifer system in the Lower Jordan Valley is mostly contaminated with the three pesticides studied (Imidacloprid, Abamectin, and β-Cyfluthrin) in higher amounts than the acceptable limit. At least one of the three pesticides was detected in the 25 groundwater samples. From the 25 samples of groundwater analyzed, detectable levels of Imidacloprid, Abamectin, and β-Cyfluthrin were found in 24, 11, and 7 samples, respectively. The total concentration of these three pesticides in the groundwater ranged from 4.72 ppb to 341.36 ppb. The lowest total concentration of the three pesticides was still higher than the acceptable limit of total pesticides for drinking water. The estimated environmental concentration of Imidacloprid in the groundwater is 2.09 ppb [29], yet it reached up to 325 ppb in the study area. Moreover, it has been estimated that Abamectin's instability as well as its low water solubility and tight binding to soil prevents it from leaching into groundwater or entering the aquatic environment. The results of this study indicate that Abamectin was found in 44% of the samples tested, with concentrations ranging between 1.24 ppb and 81.72 ppb, indicating the heavy and improper use of these pesticides in the study areas. This could result in the manifestation of several health and environmental problems. As such, immediate attention should be given to the potential problem of environmental and groundwater contamination by these pesticides.

Well depth and lithological characteristics of the sediments play an important role in the transport process of pesticides from the surface to the ground water. A time series analysis for pesticides concentration in groundwater is needed. Also, a substantive decrease in the amount of pesticides applied annually on agricultural lands in the study area is strongly recommended.

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