EFFECTS OF IRRIGATION ACTIVITIES ON THE ENVIRONMENT IN THE WEST BANK

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Abstract

This paper looks at the effects of irrigation activities on the environment in the West Bank. Irrigated agriculture covers an area of 9,472.8 hectares and utilities 93 million cubic meters of irrigation water. The current use of fertilizes in irrigated areas was found to be 18,980 tons of chemical fertilizers and 284,184 to 378,912 cubic meter of organic fertilizers. The total quantity of the pesticides used in irrigated agriculture is 152.5 tons of which 27 tons are internationally banned. Methyl bromide is a dominant material used for soil sterilization in the West Bank with a total estimated quantity of 398 tons, of which 44 percent is used in the vegetables planted under plastic houses and high plastic tunnels. Soil solarization method is only used by 0.5 percent of the surveyed farmers to control soil-born diseases. This study indicates that some farmers have faced health problems due to the spray of pesticides without using protective garments where, nineteen percent of the surveyed farmers suffer from poisoning symptoms and one percent is affected by methyl bromide fumigants. The total quantity of plastic sheets was averaged to be about 4,748 tons, at least fifty percent of which could become wastes. Eighty-eight percent of the surveyed farmers are used to collect and burn the plastic wastes on the field which could harm both the environment and the human health through smokes resulting from burning. Some water-related diseases occurred in the study area where, seventy nine persons were infected by a leishmaniasis and 14 others were infected by Dysentry. Despite the heavy use of fertilizers, water quality analysis did not show high concentration of nitrate.

Key Words: Irrigation, Environment, Quality, Groundwater, Pollution, Fertilizers, Pesticides, Sterilization, Health, Colonies.

Introduction

The optimal environmental conditions for plant growth of warmth and humidity in irrigated agriculture especially in vegetable crops under plastic houses, high and low plastic tunnels are favorable for creating and increasing various plant diseases and pests. Therefore, farmers are forced to apply various kinds of agro-chemicals to improve both the quantity and quality of the products. Irrigation activities practiced by Palestinian farmers in the West Bank may have a negative effect on both environment and human health. The aim of this study is to identify the effect of irrigation activities on the environment as well as on the human health.

Methodology

This paper focuses on the environmental impacts of the irrigation activities practiced in the West Bank. In order to achieve such aim, field survey was conducted for an area of about 2030 hectares (including 415 farmers distributed among various parts of the study area) which constitutes 22 percent of the total irrigated area in the West Bank. Analysis of the

questionnaire field data was performed to determine the quantity and quality of different agro-chemicals, plastic sheets and other irrigation by-products using the Statistical Package for Social Sciences (SPSS software). Water samples were taken from ARIJ database related to the International Development Research Center (IDRC) funded project on water resources and irrigated agriculture in the West Bank. Statistical data about areas and production of different cultivated crops are obtained through integration of the analysis of aerial photographs and the data records of the Palestinian Ministry of Agriculture.

Results and discussion

The current irrigated area in the West Bank is 9,472.8 hectares which forms 5.7 percent of the total cultivated area, with a total production of 270,570 tons which forms 47 percent of the total production of agriculture in the West Bank. Productivity of the irrigated crops in the West Bank have increased in the last twenty five years as a result of applying new irrigation technologies, the use of intensive cultivation under plastic houses, improved crop varieties, new irrigation systems as well as applying the agro-chemicals (fertilizers, pesticides and soil fumigants).

Irrigated agricultural lands in the West Bank are mainly concentrated in two regions; the Jordan Valley and the northern parts of the West Bank which includes Jenin, Nablus and Tulkarm districts.

The study shows that vegetable crops, citrus, bananas, dates, and field crops and forage are the dominant irrigated crops in the Jordan Valley whereas vegetable crops, citrus and other fruit trees are the dominant irrigated crops in the northern parts of the West Bank. Table 1 shows the total irrigated areas and production of various cropping patterns in the West Bank.

Table 1 Irrigated areas of various cropping patterns and their annual crop production in the West Bank, 1995-1996

Cropping pattern	**Area** (hectares)	**Production** (Tons)
Vegetable crops		
Open fields	4900.6	100810
Plastic houses	776.2	58464
High plastic tunnels	112.1	6022
Low plastic tunnels	306.9	10009
Sub -Total	**60958**	**175305**
Fruit trees	2814.2	90744
Field crops & forage	562.8	4521
Grand-Total	**9472.8**	**270570**

Source: Ministry of Agriculture.

The following parameters have been taken into consideration:

1. *Quality of applied water for irrigation*

At present, there is no indication that groundwater is being affected by agro-chemicals and other irrigation activities. Table 2 shows the descriptive statistics of results of analysis of water samples taken from 250 wells and springs for pH, EC, HCO3, Cl, NO3 and SAR. Table 3 shows the guidelines for interpretation of water quality for irrigation.

Table 2 Descriptive statistics of results of analysis for 250 water samples (Isaac, J., et al., 1998)

	pH	EC	HCO3	Cl	NO3	SAR
		µS/cm	ppm	ppm	ppm	
West Bank Main Springs						
Minimum	7.0	214.0	60.4	16.0	1.9	0.6
Maximum	8.0	381.0	400.2	1037.9	19.8	10.6
Average	7.5	296.7	181.1	85.9	3.9	2.1
Wells of the Jordan Valley						
Minimum	5.8	369.0	128.20	9.90	1.29	1.2
Maximum	7.4	2280.0	3720.65	2424.11	52.01	12.5
Average	7.0	1013.8	1209.50	458.61	10.02	4.4
Wells of Nablus						
Minimum	6.8	203.0	295.18	16.10	0.30	0.5
Maximum	7.7	903.0	644.34	91.80	12.96	1.8
Average	7.1	566.4	406.94	46.35	5.57	1.0
Wells of Jenin						
Minimum	6.5	268.0	49.4	22.20	0.64	0.5
Maximum	7.6	1922.0	277.0	752.43	13.22	3.9
Average	7.0	785.5	141.2	128.70	6.55	1.7
Wells of Tulkarm						
Minimum	6.6	242.0	135.57	7.80	2.81	0.2
Maximum	8.0	1623.0	1387.89	275.91	16.43	4.4
Average	7.1	648.0	496.35	66.32	8.90	1.2
Wells of Qalqilya						
Minimum	6.7	152.0	33.92	10.70	3.88	0.1
Maximum	7.7	1432.0	968.03	215.81	12.94	2.9
Average	7.0	598.5	492.04	60.64	9.57	0.8
Wells of Ramallah District						
Minimum	7.5	508.0	195.56	31.00	13.00	0.5
Maximum	7.8	585.0	244.77	36.00	21.00	0.6
Average	7.7	539.7	225.92	33.67	16.67	0.6
Wells of Bethlehem District						
Minimum	6.9	260.0	205.25	3.80	1.08	0.0
Maximum	7.3	373.0	445.79	11.80	3.18	1.3
Average	7.1	340.6	353.34	6.98	2.32	0.5
Wells of Hebron District						
Minimum	7.1	389.0	426.83	32.00	12.22	0.5
Maximum	7.3	412.0	478.04	37.60	12.23	0.7
Average	7.2	400.5	452.44	34.80	12.23	0.6

Based on the average values of different parameters shown in Table 2 above and comparing them with the standards of irrigation water quality shown in Table 3, the following notes are indicated:

- There is no restriction on water use of the main springs with respect to pH, EC, Cl, NO3 and SAR , while there is slight to moderate restriction on spring water use with respect to HCO3 for irrigation.

Table 3 Guidelines for interpretations of water quality for irrigation*

		Degree of Restriction on water use		
Potential Irrigation Problem	**Units**	**None**	**Slight to moderate**	**Severe**
Ec_w	(µS/cm)	<700	700-3000	>3000
SAR		<3	<3	
Chloride	ppm	<106.35	>106.35	
Nitrate	ppm	<21.7	21.7 to 132.68	>132.68
Bicarbonate (HCO3)	ppm	<91.53	91.53 to 518.67	>518.67
pH		Normal range (6.5 - 8.4)		

**Adapted from University of California Committee of Consultants, 1974*

- There is no restriction on water use of wells for irrigation with respect to pH and Nitrate values in all districts of the West Bank.
- In the Jordan Valley, there is slight to moderate restriction on irrigation water use of wells with respect to SAR and EC values while, severe restriction is noted with respect to HCO3 and Cl.
- In Jenin, Tulkarm, Qalqilya, Nablus, Ramallah, Bethlehem, and Hebron, there is slight to moderate restriction on water use of wells for irrigation with respect to HCO3, while there is no restriction on water use with respect to EC, Cl and SAR values.

2. Use of Fertilizers

Currently, there are two kinds of fertilizers being used in the West Bank: organic fertilizers (animal manure) and inorganic chemical fertilizers. In the growing season 95/96, the total annual volume of organic fertilizers applied in the irrigated area of the West Bank is estimated to range between 284,184 to 378,912 cubic meter based on an application rate of 30 to 40 cubic meter per hectare. The average quantities of chemical fertilizers applied per hectare per growing season for irrigated crops in the West Bank is shown in table 4. The total quantity of chemical fertilizers is estimated to be 18,980 tons in 95/96 growing season (Figure 1).

Table 4 Average quantities, in Kg/hectare, and types of chemical fertilizers applied to irrigated crops in the West Bank

Type of Fertilizer	**Quantity** (Kg/hectare)		
	Vegetables	**Fruit trees**	**Field crops & Forage**
Super phosphate	750	500	500
Compound fertilizers (N, P, K)	500	500	300
Ammonium sulphate	800	300	200
Urea	250	200	-
Micro-nutrients	15	30	-
Total	**2315**	**1530**	**1000**

Nitrogen fertilizers are mostly water soluble and the nitrate form is easily mobile in the soil. During heavy rain, irrigation process or soil leaching, nitrate is readily carried into the surface water by the runoff water, or carried downward through deep percolation. In addition, use of fertilizers may affect the chemical and physical properties of the soil by accumulating the salts in the soil producing saline soils. Large amounts of ammonia can be volatilized from manure

and other nitrogenous compounds. Volatilization process increases with the increase in the temperature. Volatilization of the ammonia can burn plant leaves and pollute the air.

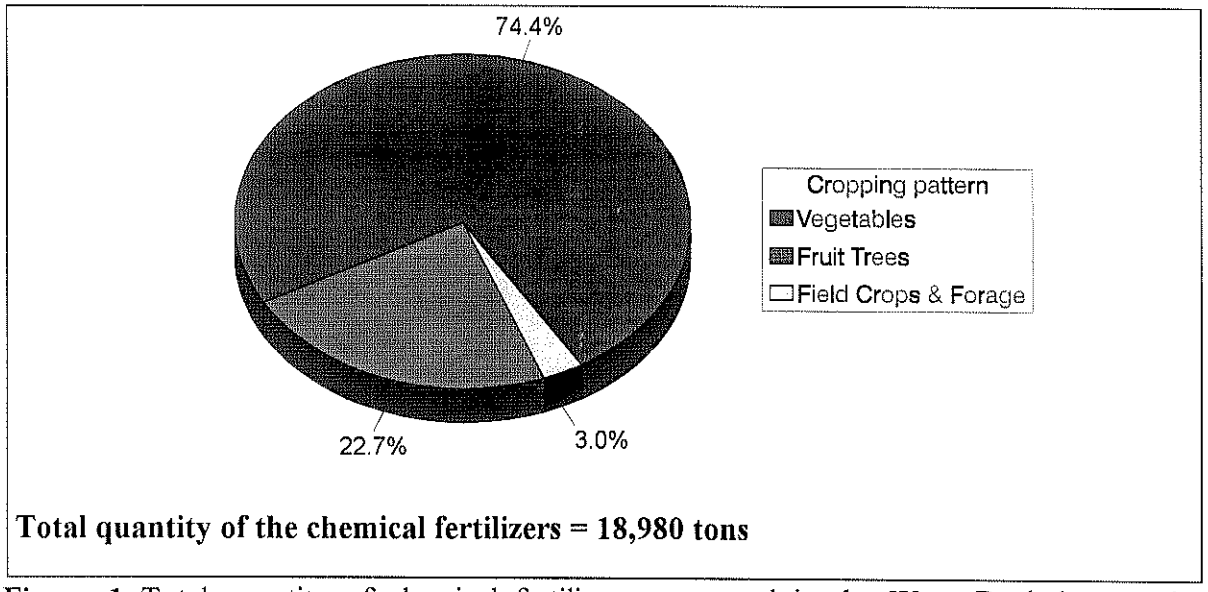
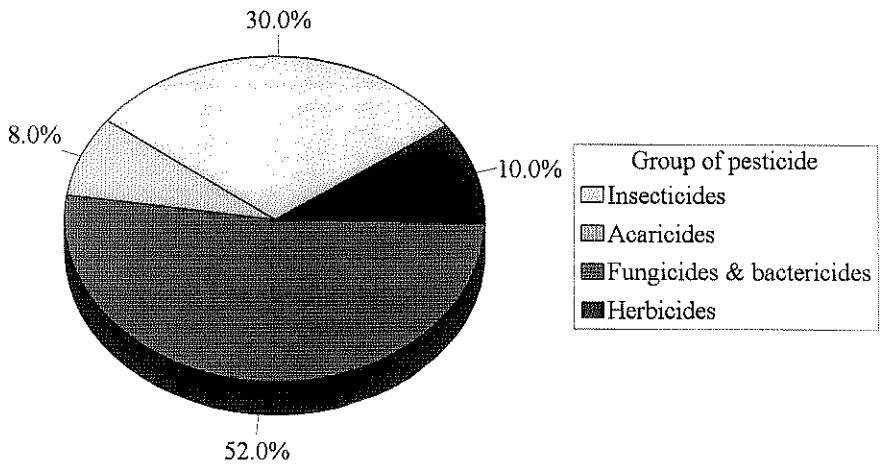


Figure 1 Total quantity of chemical fertilizers consumed in the West Bank, by cropping pattern, 95/96.

3. Use of Pesticides

The total quantity of pesticides used in irrigated agriculture in the West Bank in 95/96 growing season was 152.5 tons. Figure 2 shows the percentage of various groups of pesticides used in the West Bank. Average application rate of pesticides per growing season used by the farmers in the study area ranges between 1.4 kg/hectare in the field crops and forage and 46 kg/hectare under plastic houses (See Table 5). While in Israel the average application rate is 40 kg/irrigated hectare (Gabbay, 1994). A total of 123 pesticides are currently used in the West Bank (Saleh, et al. 1995), compared to a total of 790 pesticides are registered in Israel (Gabbay, 1994). Among these pesticides used in the West Bank, fourteen types have been internationally suspended, cancelled or banned by the World Health Organization(WHO 1993, Hassoun 1991) because of their negative impacts on the health and environment. Seven of which are members of the "dirty dozen" which are Aldicarb, Chlordane, DDT, Lindane, Paraquat, Parathion and Pentachlorophenol (PAN, 1993). Table 6 shows the quantity of the pesticides that are internationally suspended, cancelled or banned used by the surveyed farmers in this study.



Total quantity of pesticides = 152.5 tons

Figure 2 Total quantities of pesticides used in the West Bank.

Table 5 Average quantity, in Kg/hectare, and the total quantity consumed, in tons, of pesticides in the West Bank by the cropping pattern.

	Average quantity (Kg/hectare)	**Total quantity** (Ton)	**Percent of total quantity**
Vegetable crops			
Open fields	19	93	61
Plastic houses & high tunnels	46	40.8	26.8
Low plastic tunnels	22	6.7	4.3
Sub-Total		**140.5**	**92.1**
Fruit trees	4	11.2	7.4
Field crops & forage	1.4	0.8	0.5
Total		**152.5**	**100**

Table 6 Total consumption, in tons, of banned pesticides in the West Bank

Trade name	**Active ingredient**	**Quantity (tons)**
Insecticides		
Folidol	Parathion	0.9
Supracide	Methidathion	0.09
Thionex	Endosulfan	10.8
Sub-total		**11.7**
Fungicides		
Benlate	Benomyl	4
Manebgan	Maneb	5
Sub-total		**9**
Herbicides		
Albersuper	2,4,D	0.3
Dukatalon, Katalon	Paraquat, Diqnat and simazole	5.9
Stomp	Pentachloro-phenol	0.1
Sub-total		**6.3**
Grand Total		**27**

Folidol, thionex, benlate and manebgan are usually used in vegetable crops. Supracide is commonly used in citrus orchards. Albersuper is mainly used in cereal field crops such as wheat and barley. Dukatalon, katalon, and stomp are used in vegetable fields under open fields and low plastic tunnels and in the fruit trees orchards.

Nineteen percent of the farmers surveyed suffer from poisoning symptoms such as headaches, dizziness, tiredness and irritation of skin, eyes, nose and throat during the spraying operation of pesticides.

Eight percent of the farmers surveyed were affected from spraying process through inhalation, whereas 4 percent were affected through skin contamination

Sixty five percent of the farmers in the study area do not adhere to the instructions labeled on pesticide containers because they are usually labeled in Hebrew. Most of the farmers depend on their experience or on the advice of merchant of the agricultural inputs in dealing with pesticides. Seventy nine percent of the farmers don't wear appropriate protective clothing during spraying process.

About ninety percent of the farmers surveyed do not adhere with the safety period (period between the last spray and the harvest). Forty seven percent of the farmers surveyed believed that their immunity have developed against pesticides with the time through repeated usage and exposure.

Severity impacts of any pesticide on the human health from exposure to a pesticide depend on the toxicity of its active ingredient (LD50; The dose of the active ingredient needed to kill half of the number of test animals) and its formulation, dose and method of application, route of exposure, length and degree of exposure to pesticide, type of effect of the pesticide, weather conditions, metabolites and its accumulation and persistence in the body, age and health status of the person. Table 7 shows the classification of pesticides by degree of hazard. Spraying operation and volatilization of some pesticides may cause a serious air pollution.

Seventy five percent of the farmers get rid of the empty containers of pesticides by burning them at the farm borders, releasing toxic smokes into the air. Twenty percent discard them at the farm borders, these containers could be reached to the irrigation water in open canals and ponds causing water pollution, 3 percent of the farmers bury them in the soil, causing soil pollution and 2 percent collect and dispose the empty containers at a dumping site. Soil could be polluted with pesticides through direct application of pesticide such as in soil sterilization process or through indirect application through spraying operation. It has been calculated that

Table 7 Classification of pesticides by degree of hazard

		LD50 (mg/kg)			
Classification	**Description**	**Oral** (by mouth)		**Dermal** (through the skin)	
		Solid	**Liquid**	**Solid**	**Liquid**
IA	Extremely hazardous	< 5	<20	<10	<40
IB	Highly hazardous	5 - 50	20 - 200	1- 100	40 - 400
II	Moderately hazardous	50 - 500	200 - 2000	100 - 1000	400 - 4000
III	Slightly hazardous	> 500	>2000	> 1000	> 4000

Source : Arendes, w., 1989

as much as 50 percent of the pesticides sprayed on crops or used as herbicides misses its target and falls on to the soil surface. Some pesticides, notably organochlorines, may persist in the soil for years (Edwards, 1986) even though a large amount evaporates.

4. Soil Sterilization

Methyl bromide is a dominant material used for soil sterilization in the West Bank, whose active ingredient is CH_3Br. The total quantity of methyl bromide used in the agriculture in the West Bank is 398 tons in 1995-1996 growing season. Of which 44 percent is used in the vegetables planted under plastic houses and high plastic tunnels. One percent of the farmers surveyed are affected from methyl bromide fumigants. Inhaling of methyl bromide can cause a variety of acute problems, including chest pain, difficulty in breathing, and congestion of the lungs. After a short amount of time, neurological symptoms such as headaches, nausea, shortness of breath, muscle tremors and visual disturbances occur. Exposure to slightly higher levels of the fumigant can lead to the death just hours or days after exposure (WHO, 1991). Also its use can affect adversely the activity and population of beneficial micro-organisms of the soil. Methyl bromide is also an extremely potent destroyer of the ozone layer, which protects living organisms from harmful ultraviolet (UV) solar radiation (Clark, 1994). UV- B radiation affects human health in a variety of ways. It weakens the immune system, which defends the human body against disease, and has been shown to cause skin cancer and damage to eyesight (Zurer 1993). The United State Environmental Protection Agency (EPA) has classified methyl bromide as a category I acute toxin, a label reserved by EPA for the most deadly acute substances (U.S. EPA, 1986). Moreover, the earth's food chains which relies on the support of sunlight for food production, is also affected by changes in UV light exposure. The increased intensity of UV rays reduces plant production, and therefore threatens both humans and animals which depend on these plants for nutrition (Clark, 1994. Ishtaya,1995).
The Montreal protocol, an international agreement established in 1987 to eradicate ozone depleting substances, aimed to achieve a global phase-out of methyl bromide in 1995.
In November 1992, at the fourth meeting of the parties to the Montreal Protocol, methyl bromide was officially recognized as a serious ozone depleting substance. At the fifth meeting of the parties to the Montreal Protocol in November 1993, 17 countries (including the U.S., Zimbabwe, Israel, Botswana and Italy) stressed the need to strengehen the proposed phase-out plan. They declared their intention to reduce their consumption of methyl bromide by at least 25 percent by the year 2000, and to completely phase out the pesticide as soon as technically possible (UNEP 1993). The current regime gave the developing countries an additional 10 years to use this chemical. Consequently, the lack of immediate action means that methyl bromide will still to be used until 2005 in the West Bank, thus adding more pollutants to the environment and harming the health of humans.
In 1985 the Palestinian Agricultural Relief Committees used soil solarization method (solar heat treatment) to control soil-born diseases instead of methyl bromide. Good results were achieved by this experiment. Although this method is relatively cheap, effective and has no negative impacts on human health and environment, only 0.5 percent of the farmers surveyed used this method. Therefore the extension workers should play an important role in this field in order to encourage the farmers to apply this method.

5. Disposal of Used Plastic

The development in irrigated agriculture, especially in vegetables, has resulted in extensive use of plastic as pipes in irrigation networks, plastic sheets in covering the plants, soil mulching and other agricultural activities. The total quantity of plastic used in irrigated agriculture in the West Bank is 4748 tons. At least fifty percent of the total quantity of the plastic used in agriculture in the West Bank becomes solid waste.

Eighty-eight percent of the farmers surveyed collect and burn the plastic wastes on the field, releasing huge amounts of toxic smoke into the atmosphere. About 5 percent of the farmers surveyed collect the plastic wastes and dispose them at dumping sites. Others are either bury the plastic waste in the soil, which may change the physical characteristics of the soil or they dispose it at the farm borders, which may eaten by the grazing animals in the area causing health problems and even death. Thus disposing methods of plastic waste have a negative effects on the environment as well as on the human health and livestock.

Irrigation impacts on Public health

The use of pesticides, Methyl Bromide and smokes released from the burned plastic sheets and empty containers have harmed not only the physical environment but also it harmed the human beings as mentioned before in this study. There is also another impact of irrigation on the human health represented by a water-related diseases such as Dysentery and leishmaniasis (fly-borne disease). Table 8 shows the number of persons infected with water-related diseases in various districts of the West Bank.

Table 8 Number of persons infected with water-related diseases in districts of the West Bank

Disease	Jordan Valley	Jenin	Nablus	Other Districts
Leishmaniasis	50	21	4	4
Dysentery	0	12	0	2
Total	50	33	4	6

Source : Palestinian Ministry of Health, 1995

The above mentioned parameters taken into consideration includes those parameters practiced by Palestinians while, the following paragraph shows the participation of Israeli Colonies located in the West Bank in harming the Palestinian environment. The Israeli agricultural colonies in the West Bank are mostly concentrated in the areas where the water sources are available. About 92 percent of the area of these colonies are concentrated in the Jordan Valley. Based on data provided by the Israeli Central Bureau of Statistics (1996), the aggregate of agricultural areas of Israeli colonies in the West Bank amounts to 2730 hectares with total production of 42745.8 tons, in addition to 69.3 million flowers produced in these colonies (See Table 9).

Table 9 Areas, in hectares, and production, in tons, of various crop types in the Israeli colonies in the West Bank

Crop Type	Area (Hectares)	Production (Tons)
Irrigated Field Crops	270	2673
Flowers	180	*69.3
Vegetables, Potato, melons	690	21011
Citrus	280	7560
Other	1310	11501.8
Total	**2730**	**42745.8**

Source: Adapted from Israeli Central Bureau of Statistics, 1996. * Million Flowers

The current use of the agro-chemicals in the Israeli colonies was estimated based on the area provided by Israeli Central Bureau of Statistics (1996) and the data published by Gabbay (1994). The estimated quantity of the agro-chemicals in the Israeli colonies is approximately 110 tons of pesticides and 45 tons of Methyl bromide.

Conclusion

- The main springs used for irrigation are suitable for all cropping patterns without any restriction. Slight to moderate restriction is indicated on the spring water use with respect to HCO3, but the high value of HCO3 is due to the lithologic composition of the aquifer matrix draining the irrigation water and not due to the effect of irrigation practices there.
- Quality of irrigation water extracted from groundwater wells shows two different groups. The first represents the Jordan Valley and the other represents other districts of the West Bank. In the Jordan Valley, there is slight to moderate restriction on irrigation water use of wells with respect to SAR and EC values while, severe restriction is noted with respect to HCO3 and Cl. In Jenin, Tulkarm, Qalqilya, Nablus, Ramallah, Bethlehem, and Hebron, there is slight to moderate restriction on water use of wells for irrigation with respect to HCO3, while there is no restriction on water use with respect to EC, Cl and SAR values.
- Currently, there is no evidence for direct effect of fertilizers on groundwater resources of the study area since the analyzed water samples show low values of nitrates, but due to the current application of organic and inorganic chemical fertilizers, the West Bank water resources may be affected. The total quantity of the fertilizers used in the study area is 284,184 to 378,912 cubic meter of organic fertilizers and 18,980 tons of chemical fertilizers.
- Agricultural Practices in the Israeli agricultural colonies located in the West Bank could have a negative effect on the long term sustainability of the Palestinian land and water resources.

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