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# A national survey on the use of agricultural pesticides in Palestine

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This research study identifies the types and estimates the quantity of pesticides used in selected Palestinian districts. A survey of farmers (n = 126) was conducted in five districts of the West Bank and Gaza Strip, where pesticides are mostly used on irrigated land cultivated with vegetables. Data analysis of received questionnaires (87%) revealed a total number of 217 pesticides including 13 soil sterilizers, while 134 kinds with different active ingredients (insecticides 62; fungicides 45; herbicides 20) were applied in all districts. Based on the total irrigated land cultivated, the rate of pesticides per dunum reached 0.77 L in Gaza strip and 0.18 L in the West Bank districts. Contrary to earlier published data, our results support a trend of general decrease in the use of agricultural pesticides in the districts under study further to recent efforts encouraging pest management practice.

*Keywords:* Pesticides; Health risk; Environment; Pest management

## 1. Introduction

The problem of agricultural pesticides in the Arab countries is not only an issue of uncontrolled use, but also pertains to the handling, misuse and disposal of unwanted pesticides. This is exacerbated by undeveloped national laws and regulations in regard to potential fate and residuals impacts of pesticides on groundwater, food safety and public health. Extensive use of pesticides with residual contents exceeding the maximum residue limits on produce caused many European countries to ban certain agricultural exports from several Arab countries [1]. Indeed, the sale and handling of pesticides are not regulated and there is no control over the use of pesticides. Accredited labs for pesticide residue analysis are scarce in many Arab countries [2–4]. Palestine, like other Arab countries, is plagued by uncontrolled use, unsafe handling and misuse of pesticides in a proliferating range. The shortage of reliable data has alerted the scientific community and to some extent the general public to a need for facts on potential health hazards of pesticides through their indiscriminate use. [5–7]. Most agricultural land in the Palestinian National Authority (PNA) is used for food production: vegetables, orchards, and dry land crops. Using huge amounts of water and pesticides,

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Palestinians work intensively for food production: vegetables, orchards, and dry land crops, on small plots in family-owned small greenhouses, and large orchards, where agriculture employs about 30% of the 5 million PNA population [5].

Agricultural pesticides are commonly used to maintain and increase crop yields, while public health pesticides are applied to prevent vector-borne diseases. Both types are also applied in homes and gardens. Sallam and El-Ghawaby [8] have reported that uncontrolled application rates and misuse of pesticides by farmers were behind three major disastrous fatalities in Egypt. Recently, Bjørling-Poulsen et al. [9], in a review on pesticides, indicated that laboratory experimental studies with model compounds suggest that many pesticides used in Europe (including organophosphates, carbamates, pyrethroids, ethylene-bisdithiocarbamates, and chlorophenoxy herbicides) can cause neuro-developmental toxicity in humans and laboratory animals. Adverse effects on brain development can be severe and irreversible. In other cases, increased levels of pesticides residues in mother and cow milks [10,11] were reported.

In the Palestinian Territory<sup>1</sup>, West Bank and Gaza Strip, the excessive uncontrolled use of chemicals (e.g. DDT, lindane, *a*-benzene hexachloride, organochlorine, and organophosphate) for pest control and plant disease abatement has been a major issue of land based food production [5]. Increased agricultural productivity in the WB and GS has been achieved through intensified use of arable land with massive application of a variety of pesticides and fertilizers. This has led to speculation as to increased breast cancer in the Gaza Strip, and contamination of cow's milk. Tractors and backpack sprayers are the methods used to apply pesticides to orchards and greenhouses in the PNA territories [2,6,12]. There is, however, little documented information on quantities and qualities, types and sales and actual application rates.

The fate and impact of pesticides application in the PNA is likely to remain unknown, while the local scientific community is not experienced in making the required studies. Lack of national regulation on pesticide use, prohibition of pesticides placing on the market and use of plant protection products containing certain active substances are outstanding environmental issues [3,9,13]. No official information is available on anecdotal reports of the sale of restricted pesticides by Israel to the PNA and other anecdotal reports that Israeli farmers buy back cut-rate pesticides sold to PNA distributors [6,9]. Thus, it is necessary to develop a regulatory system which includes accurate record keeping.

## 2. Materials and methods

The main purpose of conducting the national pesticides survey (NPS) is to evaluate pesticides rationally used in a sustainable manner in terms of quantities and qualities, in order to assist the policy/decision makers to achieve a regulatory system. Three PNA districts - Jericho, Jenin and Gaza - are targeted as pilot areas. We performed a detailed literature survey as to pesticides regulations, applications in agriculture and public health sector (insecticides). The literature survey revealed that there were few unpublished reports from national authorities. The only published scientific literature concerns pesticides use in the agricultural sector of the Gaza Strip. There is no free access to data published except for one refereed article published by Safi [2] and Yassin et al. [14]. The knowledge, attitude, practice, and toxicity symptoms related to pesticide use in the Gaza Strip were described via a questionnaire distributed to farm workers.

### 3. Results and discussion

#### 3.1. Local literature survey and pesticides registration and use in the West Bank governorates

According to the Israeli Ministry of Agriculture [15], there are about 1019 registered pesticides in Israel. For organic farming about 154 chemical substances are in use including pesticides, and pheromones and insect attractants. In 2004, the Palestinian side applied about 464 active substances (more than 900 pesticides). In cooperation with Adam Smith, a British pesticides expert, the Palestinian National Committee identified in 2007 only 242 active ingredients that are adequate for use and permitted for application in the agricultural and public health sectors [16].

Analysis of the annual pesticides applications in agricultural farms within the northern districts of the West Bank revealed a drastic reduction in the quantities used for all pesticide types. It is estimated that only 770 tonnes of pesticides were applied in Palestine’s agricultural sector during 1996, compared with 979 tonnes of pesticides during the year 2006 [16]. Figure 1 shows the total annual amounts of pesticides used over the past 12 years (1996 - 2007). Compared with 1996, the amount applied during 2007 revealed a reduction in the various types (30% insecticides, around 53% fungicides, 64% herbicides, 20% entails soil disinfecting agents [16]. The national scientific committee on pesticides control, established in 1999, was reactivated with new members only from the West Bank in 2007 due to political instability in Gaza strip. A Palestinian regulation on pesticides registration is ready for approval by the national cabinet [17].

The data presented in Figure 1 show a sharp decrease (65%) in the annual quantities of the main agricultural pesticides (insecticides, fungicides, and herbicides) including soil disinfecting chemicals and other types of pesticides between year 2007 and 1996 in the northern West Bank districts.

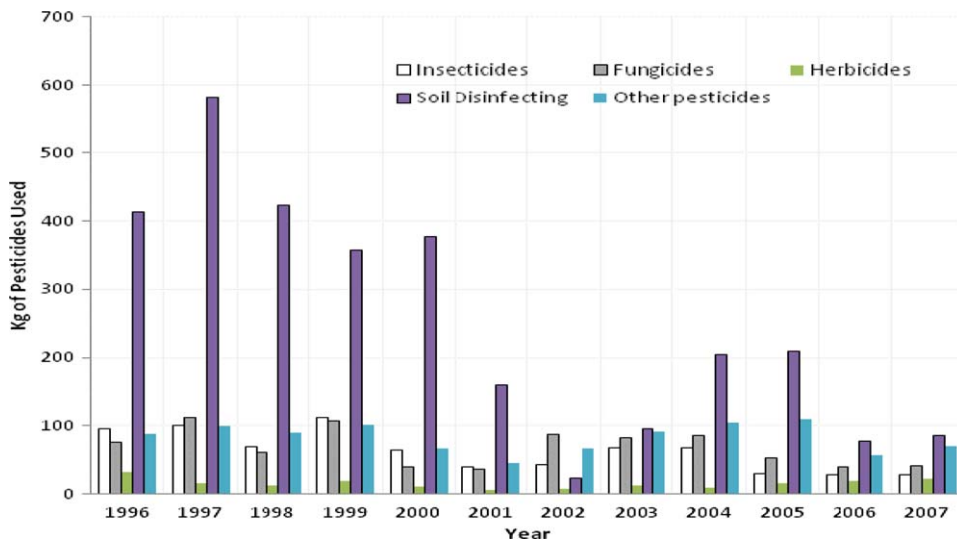


Figure 1. Estimated annual pesticides quantities (kg) for the northern West Bank Districts.

### 3.2. Pesticides application in Gaza Strip Governorates

During an epidemiological study conducted over 10 years (1990-1999), Yassin *et al* [14] reported that farmers applied several banned and potential hazardous pesticides despite known carcinogenicity, genotoxicity and cytotoxicity. Total recorded hospital cancer cases in men (2277) and women (2458) revealed a strong relationship with extensive pesticides exposure. According to Yassin *et al.* [14], the adverse public health impacts caused by the misuse of pesticides are well-known, especially under uncontrolled pesticides usage in Gaza Governorates, where they ranged from 216.9 to 393.3 tonnes from 1990 to 1999, respectively. Regarding toxicity symptoms associated with pesticides, Safi [2] showed that common self-reported toxicity symptoms among farm workers were burning sensation in the eyes/face, dizziness, cold/breathlessness/chest pain, itching/skin irritation, and headache. He called for urgent prevention, intervention, and protection from the Ministry of Health and other non-governmental organizations.

In Palestine, as in many other developing countries, lack of regular pesticides analysis and control in groundwater makes it difficult to integrate knowledge and to examine their relation to the soil under local conditions. More than 1000 tonnes of pesticides used in Gaza Strip represented 75 different kind of pesticides, 19 of which were internationally prohibited [2]. For comparison, Table 1 lists the amounts of pesticides applied during the years 2004 until 2006 [16].

The impact of pesticides application in the PNA is likely to remain unknown to the public because the scientific community lacks experience in this field of work. Concern about the environmental impact of repeated pesticide use has prompted research into the environmental fate of these agents, which can emigrate from treated fields to air, soil and water bodies [18–20].

The following points play an important role in the movement of pesticides:

- The more soil microbial communities are active and capable to degrade pesticides, the lower will be the levels of pesticides and their metabolites released to the groundwater.
- In winter, with increased rainfall and a temperature drop below the biological activity of micro-organisms, there is a greater chance of laundering these substances into the groundwater.
- pH deviation from a point affects the activity of micro-organisms and thus reduces the potential of pesticides degradation.

Table 1. Importable quantities of pesticides in Gaza Strip (2004 - 2006)\*.

Materials	Quantity (Ton) 2004	Quantity (Ton) 2005	Quantity (Ton) 2006
Insecticides	95	42	38.5
Fungicides	120	74	55
Herbicides	12.5	20	24.9
Methyl Bromide	293	300	111
Hormones	4.5	300	8
Attractive Materials	50	–	17
Nematicides	33	14	–
Others	3.8	1	–

\*Source: Ministry of Agriculture (MoA) [16].

Aly and Schröder [21] have examined pesticides impact on ecosystem and soil microflora. The health implications of pesticides usage on farmers were surveyed by Lu and Cosca [22] in regard to farmers in the Philippines, where about 51% of the respondents (542) engaged in vegetable production had become ill due to unsafe mixing and spray of pesticides.

The aim of this inquiry is to establish a database on commonly used pesticides in agriculture, identify their types and estimate the annual quantities. This will enhance record keeping and thus assist policy makers to advise on control and monitoring of pesticides usage in the agricultural sector. The potential environmental impacts of pesticides used in both irrigated agricultural farms and rain-fed olive groves are unknown, and warrant further investigation, but this is beyond the scope of this study.

### 3.3. Results of pesticides survey in selected Palestinian districts

#### 3.3.1. Types and quantities of agricultural pesticides used in the West Bank districts

Depending on the crops cultivated, the results of the questionnaires revealed variations in the types of agricultural pesticides used in Jenin, and Jericho districts; about 90 and 72 types of pesticides that are commonly used, respectively. These figures reflect the fact that the results concern 86.5% of questionnaires [109collected] after completion by the respondents [126 total distributed]. The total area of agricultural farms (open and closed type) in the West Bank districts under study is about 5608 dunums, which makes about 5.6% of total land irrigated for producing vegetables. Most cultivated crops are vegetables (tomato and cucumber).

The total quantity of pesticides, including soil sterilizers and other chemicals applied in the West Bank districts, was given by the respondents as 1233.4 L (0.22 L/dunum). Figure 2 depicts the insecticides with the highest percentage (25.5%) compared with fungicides and herbicides, 17.8% and 7.4%, respectively. It is noteworthy that additional soil sterilizers (boron) and other types of inorganic chemicals (non-pesticides) are used with 23.8% and 26.3%, respectively.

The Palestinian Central Bureau for Statistics (PCBS) [23], published recent data for the West Bank on the total irrigated agricultural land area of 100,781 dunums (open and closed), and cultivated with vegetables.

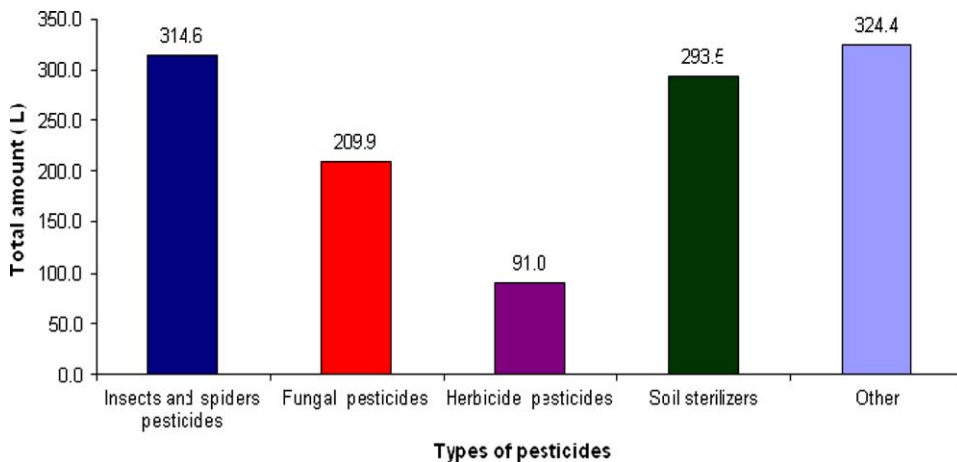


Figure 2. Types and total amount of various pesticides applied in West Bank districts.

Multiplying the specific annual application rate of 0.18 L/dunum (without soil fertilizers) by the total irrigated land cultivated with vegetables yields a total for pesticides applied of 18.1 tonnes. Comparing data on pesticides published by the Applied Research Institute Jerusalem [5], we believe our results indicate a reduction in pesticides application rates in the agricultural sector. Recent promotion of integrated pest management (IPM) by the Ministry of Agriculture might be behind the reduced application rates.

### 3.3.2. Types and quantities of agricultural pesticides used in Gaza Strip districts

The data obtained from the questionnaires revealed 68 different kinds of pesticides that are commonly used in the agricultural sector in Gaza Strip. The total area of agricultural farms (open and closed type) is about 506 dunums, which is around 1% of total irrigated land with vegetables. Most cultivated crops are vegetables (tomato, cucumber and strawberry).

Major findings on the pesticides survey in the Gaza Strip are listed below:

1. Vertimec is found to be the common pesticide, which is intensively used in the two target areas. The common pesticides used in the two target areas are shown in table 2.
2. The initial results showed that pesticide usage is greater in areas of intensive and high value crop cultivation. More pesticides are used for crops grown under plastic than for those grown in open irrigation systems.
3. The survey reveals widespread problems in both usage and disposal of pesticides. Most labelling is in Hebrew which most Palestinian farmers cannot read. A relatively limited number of farmers in Gaza Strip said that they read and followed advice given in agricultural publications. Most of the farmers interviewed mainly depend on their own knowledge and experience at the application of pesticides.
4. The initial results showed that the farmers are rarely committed to the recommended doses of the pesticides. Most of the interviewed farmers seldom followed the instructions for maintaining a safety period, though some know the danger of harvesting the crops too soon.
5. The data show the total annual tonnage used in agriculture in the Gaza Strip ranges from 500-700 tonnes/year, which leads to an annual average of 3.84 kg/dunum of pesticide used in the target areas.
6. Despite the high risk and frequency of exposure, farmers did not wear proper personal protection like gloves, cloth face and boots while working with pesticides.

The size of the agricultural land in the Gaza Strip is given as 506 dunums, with a total for pesticides during the agricultural season of about 1942.2 litres (3.84 L per dunum).

Table 2. Commonly used pesticides (trade name/active substance) in Gaza agricultural fields

Open Field agriculture (Strawberry)	Intensive agriculture (Greenhouses)
Vertimec (Abamectin)	Vertimec (Abamectin)
Match (Lufenuron)	Evisect S (Thiocyclam hydrogen Oxalate)
Rovral 50 (Iprodione)	Smash (Fenprothrin)
Bavistin (Carbendazim)	Tamaron (Methamidophos)
Ronstar (Oxadiazone)	Ofir (Penconazole)
Sencor 70 (Metribuzin)	Afugan (Pyrazophos)

Figure 3 shows the total amount of pesticides including soil sterilizers and other chemical substances applied in the agricultural sector (L) during the agricultural season for 2008. Among the total quantity, the percentage of soil sterilizers as a chemical substance is the highest (80.04%) compared with insecticides, fungicides, herbicides and others (6.0%, 10.97%, and 0.55%, 2.45% respectively). Considering only the pesticides applied without soil fertilizers would give a specific value of 0.77 L/dunum. Similarly, taking the recent data published by the PCBS [23] on total irrigated land cultivated with vegetables in the Gaza Strip (50,292 dunums; open and closed areas) revealed a total pesticides quantity of about 38.7 kg/dunum. This amount (68%) is higher than the total annual pesticides applied on vegetable producing land in the West Bank, although the total irrigated land in the Gaza Strip is only 33.3% of the total vegetable producing irrigated land in Palestine.

### 3.3.3. Attitude and awareness of farmers towards pesticides hazards

The questionnaires distributed to different groups of farmers in rural and urban areas within Jenin, Tubas and Gaza Strip districts were collected and statistically analysed. Table 3 summarizes the answers given by the respondents to various questions. It is obvious from the data listed in Table 3 that more than 25% of respondents are neutral in opinion, most likely unaware of negative effects of pesticides on biodiversity (birds, bees, soil ecosystem). More than 80% of replies were unaware of potential impacts on groundwater and air pollution. There is an urgent need for education on pesticides. Andersch and Anderson [23] showed that 31 pesticides (15 insecticides, 10 fungicides, and 6 herbicides) when applied at recommended doses had no long term (greater than 90 day) influence on soil nitrogen mineralization. Nevertheless, in the absence of national regulations on sustainable use of pesticides, excessive use of pesticides might lead to detectable concentrations in breast milk and enter groundwater and surface water [10,11,24,25].

A major concern is that about 86.3% of respondents cannot read instructions on pesticides labels, as most of them are either in Hebrew or English, and 95.4% rely on their own experience for the dose amount and calibration.

Current practices of Palestinian farmers in the use and disposal of pesticides might pose serious health and environmental risks, especially for children (2% of farm workers) and

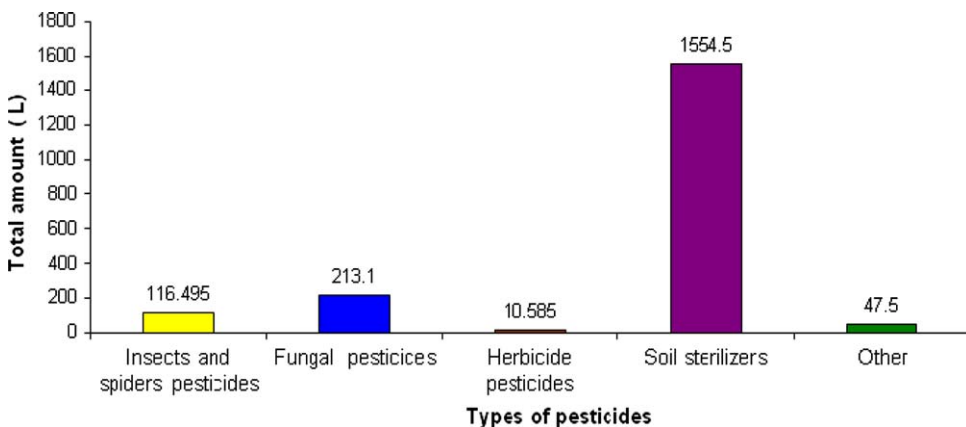


Figure 3. Types and total amount of various pesticides applied in the Gaza Strip.



Table 3. Farmers attitudes towards adverse impact of pesticide use in agriculture.

Items (sample size 109 questionnaires)	Completely Agree Number (%)	Agree Number (%)	Neutral Number (%)	Disagree Number (%)	Totally Disagree Number (%)
Wrong use of pesticides could lead to the human death	19 (17.4)	73 (67)	11 (10.1)	4 (3.7)	2 (1.8)
Wrong pesticides use could lead to damage human health	29 (26.6)	54 (94.5)	11 (10.1)	12 (11)	3 (2.8)
Wrong pesticides use could lead to damage animal health	29 (26.6)	60 (55)	6 (5.5)	11 (10.1)	3 (2.8)
Use of pesticides contributes to the elimination of beneficial organisms in the soil and nature	17 (15.6)	38 (34.9)	26 (23.9)	21 (19.3)	7 (6.4)
Use of pesticides kills the bees	20 (18.3)	43 (39.4)	24 (22)	20 (18.3)	2 (1.8)
Use of pesticides kills the birds	17 (15.6)	48 (44)	23 (21.1)	20 (18.3)	1 (0.9)
Pesticides contribute to pollution and reduce soil fertility	18 (16.5)	43 (39.4)	31 (28.4)	14 (12.8)	3 (2.8)
Use of pesticides leads to burn or distorted the plants	11 (10.1)	36 (33)	43 (39.4)	15 (13.8)	4 (3.7)
Use of pesticides causes air pollution by toxic compounds	17 (15.6)	61 (56)	18 (16.5)	8 (7.3)	5 (4.6)
Use of pesticides leads to damage ozone	7 (6.4)	16 (14.7)	4 (3.7)	7 (6.4)	75 (68.8)
Use of pesticides leads to groundwater pollution	11 (10.1)	12 (11)	4 (3.7)	7 (6.4)	75 (68.8)



Figure 4. Unsafe mixing of pesticides.

old farm workers (11% of farm workers). Figure 4 illustrates this problem. The photograph is one of several showing improper storage, unsafe mixing and spraying behaviour (Figure 4), and unhealthy disposal techniques.

The survey indicates that a high percentage (65.6%) of respondents (160 farmers) reported symptoms resulting from direct pesticides usage. Farmers reported a few cases of death caused by incorrect handling of pesticides (S. Sawalhi, General Primary Health Care and Public Health Directorate, Ministry of Health, personal communication). Similar health hazards were reported recently by Lu and Cosca [22], where about 51% of the survey group of farmers in the Philippines (542) engaged in vegetable production reported health implications due to unsafe mixing and spray of pesticides. Andersch and Anderson [24] showed that 31 pesticides (15 insecticides, 10 fungicides, and 6 herbicides) when applied at recommended doses had no long term (greater than 90 day) influence on soil nitrogen mineralization. Nevertheless, in the absence of national regulations on sustainable use of pesticides, excessive use of pesticides might lead to detectable concentrations in breast milk and enter groundwater and surface water [10–12] [22,25,26].

#### 4. Conclusions and recommendations

This study has provided a quantitative synthesis of accessible information with regard to estimating the use of pesticides and the awareness of farm workers and public health

inspectors on the potential risk of misuse. The MoH and MoA require strong management to control hazardous and toxic pesticides in public health and agricultural sectors. Relevant authorities, the Palestinian Water Authority and the Environmental Quality Authority must improve sanitation and solid waste services to minimize water pollution to domestic and agricultural wells (groundwater) by pesticide toxicants.

The majority of respondents indicate that they are aware of hazardous impacts of pesticides, but they give unjustified arguments on applying safety measures for usage, storage or disposal of used pesticides bottles or obsolete residues. It is necessary for the farmers to use pesticides with low water solubility instead of pesticides with high solubility, and agricultural farm schools should help farmers by providing adequate information. Furthermore, there is a need for specialized agricultural health and safety programs in First Aid and health care procedures for emergencies. Regular training and health monitoring of farm works by medical professions specialized in the medical issues of domestic and agricultural pesticides use should also be encouraged.

Chemical decomposition and microbial biodegradation in the drainage channels of paddy fields must be strengthened by increasing the aquatic purification capacity. This can be done by extending the residence time, by placing barriers and other obstacles on the river bed, for example, in a zigzag fashion on both sides of the river. Cement or brick blocks are examples of appropriate obstacles. Advance analyses of surface water, groundwater, rivers, and coastal water by water authorities are necessary.

Technical guidelines on pesticide storage, stock control, disposal of both bulk and small quantities of unwanted and obsolete pesticides with technical provision are also recommended. Control and monitoring of pesticides usage, evaluation of pesticides residues, pollution assessment of soil, produce and aquatic environment are urgently needed to minimize adverse pesticides impacts. Flux quantification of agricultural pesticides from land-to-sea (Gaza Strip) and land-to-groundwater (West Bank and Gaza Strip), among other allochthonous organic substances, is useful. By this kind of monitoring, in both urban and rural areas, problems of water quality can be identified, controlled and managed - even if they cannot be solved or prevented! Flux quantification is applicable in both surface and groundwater bodies. It also protects soil from degradation and public health. Groundwater protection in Palestine is a relatively new environmental field. Laws, institutions, and policies have to be developed and have to be applied at the local level. This needs to include taking into account the regional experience and political commitments with neighbouring countries.

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### *Note*

1. According to World Bank definition, West Bank and Gaza Strip are considered as Palestinian Occupied Territory (OPT), under the rule of the Palestinian Authority (PA).

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