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Farmers' attitude toward treated sludge use in the villages of West Bank, Palestine

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Abstract An application of treated sewage sludge on agricultural land has been widely accepted, as this method is simple and economical for disposal of wastewater residues. When applied properly on an agricultural land, sludge can replenish organic matter and nutrients in soil. Although sewage sludge has been used in agriculture in many parts of the world, its acceptability varies with different cultures and beliefs among farmers. Farmers' concerns on sludge use are primarily due to its anthropogenic origin, pollutants that it carries, a general perception of sewage being dirty, and its offensive odor. This paper aims to investigate farmers' perceptions on land application of treated sewage sludge on their farm. This study targeted two farming communities, namely, Anza and Beit Dajan villages, located in Jenin and Nablus districts in the West Bank, Palestine. In this study, a sample of 106 farmers were randomly selected and surveyed through a mixture of structured and open-ended questions. Results indicated that, overall, farmers have positive perceptions on land application of sludge. A majority of the farmers are in favor of the concept of sludge use when a planned wastewater treatment plant is constructed and it becomes operational. Results also indicate that a majority of the farmers are in favor of using sludge for fertilizing fruit trees, rather than growing vegetables and other plants in a greenhouse, and that many of them have knowledge of sludge properties and advantages and disadvantages of sludge use in agriculture. Despite the positive perceptions by the majority of farmers, a small fraction of the farmers are in disfavor of the use of sludge for the following reasons: psychological and social concerns, potential health risks, and their religious beliefs. Results further suggest that the land application of treated sewage sludge can be accepted by more farmers if the consumers are willing to buy agricultural products fertilized by sludge, sludge meets the public health requirements, and sludge is available at low costs. To improve farmers' perceptions on the land application of sludge, several measures are recommended.

Keywords Land application · Agriculture · Sewage sludge · Farmers' perception · Fertilizer · West Bank

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Introduction

Treated sewage sludge, also known as bio-solids, is residues of suspended solids in sewage after being settled and separated through wastewater treatment

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processes. Sludge consists of solid, semi-solid, or liquid waste (United States Environmental Protection Agency 2016), and contains approximately 3% solid on weight basis. Treated sludge generally contains stabilized organic matter and nutrients (i.e., N, P, K, Ca, and Mg); thus, it has agricultural values. Nutrients contained in sludge can be safely used as fertilizer to stimulate plant growth and thus can increase crop harvest (European Commission 2001; Pasda et al. 2005; United States Environmental Protection Agency 2016).

Land applications of sewage sludge

An increase of population and urbanization has resulted in a significant increase in wastewater generation in many countries. Consequently, the generation of sludge has also increased as one of the end products of wastewater treatment processes. Sustainability of wastewater treatment processes depend on the safety and economics of sludge disposal. One of the most economical and widely accepted final disposal methods of sludge is land application (Tchobanoglous et al. 2002).

In a study by Bittencourt et al. (2014), 33,404 t of dry sludge was applied to 2288 ha of agricultural land in Brazil. Their results showed that the sludge supplemented 88% of the required lime, 74% of nitrogen, 73% of P_2O_5, and 35% of K_2O for the production of corn, soybean, bean, oat, and fruit trees. By using sludge, the farmers reduced fertilizer costs and saved $814/ha on average. In a study of land application of sludge in Bangkok, Thailand, Pasda et al. (2006) reported the presence of heavy metals and fecal coliforms in sludge. They suggested that sludge should be heated by composting to reduce pathogen population. Vasseur et al. (1999) studied the factors that could limit land application of sludge in southern Quebec, Canada. They reported that Quebec's regulatory standards allow using only a certain portion of the sludge for land application. Many municipalities cannot use sludge in agriculture due to heavy metal contamination of sludge. The other factors that potentially limit the land application include limited available land areas, presence of pathogens, climatic constraints, and costs for transportation and storage of sludge.

Sludge management legislation and practices in European Union countries

The European Union (EU), which comprises 27 independent member states, is further divided into EU 15, consisting of 15 member states, and EU 12, consisting of 12 member states. These member states are required to enact EU Regulations and Directives into their own national legislations.

Sludge management Directives: During the last 30 years, sludge management in EU countries has been regulated, directly and indirectly by legislative tools, acts, and Directives. Among them, Directive 86/278/EEC (adopted in 1986) and Directive 91/271/EEC (adopted in 1991) have the most significant impact. Directive 86/278/EEC sets rules on how farmers can use sewage sludge as a fertilizer to prevent it from harming the soil, vegetation, animals, and human health without compromising the quality of the soil or surface water and groundwater. It sets specific limits on the concentrations of seven heavy metals allowed in soil that may be toxic to plants and humans. Since the adoption of this Directive, many member states have enacted and implemented stricter limit values for heavy metals and other contaminants (European Communities Commission 1986).

Due to the implementation of Directive 91/271/EEC, known as Urban Waste Water Treatment Directive, the quantity of sludge requiring disposal has increased and the quality of sludge has substantially improved in the EU 15 states during 2000–2010. This Directive bans the disposal of sludge at sea (by December 31, 1998), resulting in two options for sludge management, recycling to agricultural land or disposal to landfill (Inglezakis et al. 2011a, b).

Sludge application to agricultural land: During the last 30 years, many researchers have studied bio-solid application practices in Europe. Evans (2012) reported that overall 37% of bio-solids produced in EU are recycled to agriculture. However, the range for different member states extends from more than 70 to 0.006%. Contrary to the myths, overall more than 50% of the bio-solids are used on farmland. Landfilling of sludge is negligible.

Milieu (2010) reported sludge application on land. During 2003–2006, about 10 million tons of dry solid of sludge was produced in the EU, consisting of 8.7 million tons in EU 15 member states and 1.2 million tons in EU

12 member states. Though 37% of this sludge was recycled in agriculture, this proportion varies widely among the member states. For example, in Belgium, Denmark, Spain, France, Ireland, and the UK, this proportion is 50% or more. In Greece, Netherlands, Romania, Slovenia, and Slovakia, this proportion is 0% or no application of sludge to agricultural land.

Research by Hall (1995) indicates that over 30% of sludge is used as fertilizer in agriculture in the European community. Davis (1987) reported that the annual production of dry sludge is approximately 1.2 million tons in the UK, of which 40% is utilized on agricultural land.

Debate on sludge application to agricultural land: European Commission (2001) studied the disposal and recycling routes for sewage sludge. The debate on the use of sludge in agriculture originated mainly in Northern Europe at the beginning of the 1990s, before gaining in intensity from 1995 onwards. The debate is more "advance" in Northern Europe, but remains limited in Southern Europe. The debate is heated in Austria, France, Germany, and Sweden. Based on various stakeholders' attitudes, motivations, and constraints concerning the use of sludge, the following observations are made:

- The regulatory requirements have prevented almost all use of sewage sludge in agriculture since 1991 in the Netherlands and since 1999 in Belgium. In Denmark, new regulations on the use of sludge in agriculture (Statutory Order no. 49) are considered sufficiently strict to reduce risks to an acceptable level. In the UK, an agreement was reached in September 1998 for supporting the agricultural use of sludge, both for economic and for agronomic reasons.
- In Sweden, a voluntary agreement was signed in 1994 concerning quality assurances relating to the use of sludge in agriculture. In Germany, opinion has swung in favor of sludge spreading on agricultural land.
- In Austria and France, agreement is currently under negotiation between the different parties, and hence the debate is heated. In France, farmers' unions supported the development of the agricultural recycling of sewage sludge, on the condition that additional quality controls and an insurance fund system were set up.
- In Finland and Luxembourg, the farming community is generally hostile toward the use of sludge for land spreading, mainly because of the pressure to use animal manure for land spreading. In Ireland and Portugal, farmers support, in some cases, the agricultural use of sludge, both for economic and for agronomic reasons.
- In Ireland and Portugal, farmers support, in some cases, the agricultural use of sludge, both for economic and for agronomic reasons. In both countries, the use of sludge seems to be too recent an issue to generate much public debate. In Spain, Italy, and Greece, the debate remains limited.

Laws and standards regarding land applications of sludge

Currently, there are no laws, rules, or regulations that require, recommend, and/or prohibit application of sludge for agricultural purposes in the West Bank. Since the bulk of the territory of the West Bank is now under Israeli control, effort was made to examine agricultural practices of sludge in Israel to identify if there is any Israeli law that applies to land application of sludge.

In Israel, the treated sewage has been dumped into the sea for decades causing one of the greatest pollutants in the Mediterranean Sea. However, this practice has been partially stopped following a decision by the Israel Environmental Protection Ministry in 2007. According to this decision, the sludge will be turned into fertilizer (Central Israel to Stop Dumping Sewage Sludge into Mediterranean Sea 2016). According to a study in 2011, approximately 94% of the sludge was being reprocessed and was used as fertilizer. In 2010, approximately 63,000 t of sludge was processed into compost for agricultural use in Israel (Israel Reusing Sewage Sludge as Fertilizer 2011).

Despite this aforementioned transformation of sludge application, Israel has not adopted any formal laws, rules, or regulations that require, recommend, and/or prohibit agricultural application of sludge either in Israel or in the West Bank. The closest relevant rules or standards for agricultural sludge application were found in neighboring country, Jordan.

According to the Jordanian Standard (JS 1145-2006), sludge is classified into three types (i.e., types I, II, and III) based on heavy metal content and level of treatment necessary to reduce the pathogen content. Both type I and II sludge can be used for agriculture (i.e., as soil amendment); however, type II can only be used as a soil amendment during land preparation in areas not

accessible to the public (i.e., public parks). Type III sludge is permitted to be landfilled, in addition to type I and II sludge (Matar 2013).

Advantages and disadvantages of land applications of sludge

Organic matters in sludge can improve physical properties of soil, namely, soil's ability to absorb and store moisture (European Commission 2001; Sripanomtanakorn and Polprasert 2001; United States Environmental Protection Agency 2016). Over time, the use of farmland can result in the depletion of organic matter in soil. Because sludge can replenish organic matter in soil and add nutrients at least partially in soil, the use of sludge can reduce the costs of crop production. Treated sewage sludge is considerably less expensive than the fertilizers manufactured in a chemical plant. In the European farming communities, over 30% of sewage sludge is being used as fertilizer (Wang et al. 2008). The positive aspects of sludge as a fertilizer and soil amendment have created the high sludge demand (Pritchard et al. 2010).

Despite the increasing use of sewage sludge, there are major drawbacks, as follows: (a) potential presence of heavy metals, organic pollutants, and pathogens, which can accumulate in sludge (Wang 1997); and (b) offensive odors produced by sludge. These drawbacks pose public health and environmental issues (National Academy of Sciences 1996). These disadvantages, however, can be minimized by choosing suitable crops, adopting proper sludge spreading techniques, and regulating the time between sludge applications and harvesting (Dahlstrom 2005). Singh and Agrawal (2008) suggested performing prior assessments of characteristics of soil, sludge, and species of crops to be grown. Although sludge use in farming is a common practice in many low-income countries, its acceptability varies among farmers with different cultures (Keraita et al. 2008) for the following reasons: its anthropogenic origin, the general perception of sewage being dirty, and its offensive odor. Therefore, examining farmers' perception and attitude toward land application of sludge is vital.

Perception of sewage sludge application

A few studies have targeted farmers' perception and attitude on land application of sewage sludge. Using a survey method with randomly selected farmers (sample size, n = 139) in the Gaza Strip, Nassar et al. (2009) studied attitudes of farmers focusing farmers' acceptance and willingness to use sludge as an alternative to organic fertilizers. Their survey questionnaires were designed based on the assumption that many of the farmers are not well-educated and have limited knowledge on the land application of sludge. Their results revealed that (a) the scarcity and high prices of organic fertilizers could encourage farmers to use sludge if adequate quantities of sludge are available when needed; (b) those farmers who have no experience in using sludge may be willing to use sludge if it is well treated, its application shows good results, and it is safe to handle; and (c) most farmers prefer to use sludge for fertilizing trees and field crops, rather than growing all types of crops. Yassin and Abed Rabou (2002) identified the reasons why farmers have not used sludge in agriculture in the northern Gaza Strip, including the following: (a) sludge is perceived as a spiritually polluting matter; (b) sludge may kill crops; and (c) sludge contains pathogens, attracts insects, and produces odors. Their study indicated, however, that an availability of inexpensive, safe, and effective sludge can influence farmers to use sludge. The farmers' willingness to pay for sludge depends on its quality and safety for its application.

By interviewing 50 fruit and vegetable farmers in Southern New Jersey, USA, Krogmann et al. (2000) studied farmers' perceptions and choices regarding land application of sludge. Their survey showed that an application of sludge is not a common agricultural practice in New Jersey, due to the following factors: (a) presence of heavy metals in sludge, (b) negative public perception, (c) odor, and (d) potential increase of contaminants in water supply systems. In southern New Jersey, vegetables and fruits are major commodities and consumers may be sensitive to produce or eat crops that have been in contact with sewage sludge directly or indirectly. A study by Krogmann et al. (2000) showed that farmers realized the benefits and drawbacks of using sludge despite its unfavorable perceptions. The farmers recognized that an application of sludge can increase organic matter in soil and improve the property of soil and may increase crop productions. The farmers were, however, more concerned about the conditions of their land and were less concerned about the environment and health risks that sludge may cause. Approximately 36% of vegetable growers indicated that

they were interested in obtaining more information, indicating that there is insufficient information available to them about land application of sewage sludge.

Peterson et al. (1994) conducted a pilot (non-random sampling) study at Iowa State University, Iowa, USA. In their study, a sample of 68 Iowa farmers (most of them were relatively well educated) were asked about land application of sludge. In their survey, 38% of the farmers agreed somewhat or strongly that land application of sludge poses a threat to their health and well-being. Farmers' perception about the use of excreta was studied in Southern Ghana by Adeotia et al. (2010). Their results showed no cultural and religious barriers for the use of excreta in crop cultivation.

In the West Bank, Arafat (2013) studied the public awareness about the sustainable use of treated wastewater in agriculture. Technical workshops were held to provide training on the subjects related to wastewater targeting students, householders, women, and farmers in several villages. The purpose of the campaign was to raise the cultural awareness and knowledge to empower human and institutional capacities. The participants in the workshops and surveys included 496 students, 39 farmers, and 108 householders. The survey results indicated that the training workshops increased students' knowledge about wastewater, wastewater treatment, and sludge use as fertilizers. The workshop increased the householders' willingness to assist in wastewater treatment and reuse of treated wastewater for irrigation. These efforts also increased the farmers' willingness to reuse treated wastewater for irrigation, and the consumption of agricultural products harvested from the farm irrigated by treated wastewater. The author recommended that priority should be given to public awareness programs in the strategic planning for wastewater projects.

This paper aims to investigate perceptions and attitudes of West Bank village farmers toward the use of sludge as an alternative to imported organic fertilizers. In this study, farmers in two villages, namely, Anza and Beit Dajan of the West Bank, were randomly chosen. These villages are located in the Jenin and Nablus districts of Palestinian Territory (Fig. 1). Recently, two wastewater treatment plants (WWTPs) to serve Anza and Beit Dajan villages have been built. These two WWTP facilities generate substantial quantities of treated wastewater and sludge. It is expected that an effective use of treated wastewater and sludge will increase irrigated areas to grow fruit trees and crops in Anza and Beit Dajan. Although attitudes of farmers toward an agricultural application of sludge were studied in Gaza (Nassar et al. 2009), no studies have attempted to identify farmers' perception in areas of the West Bank. The specific objectives of the present study are (a) to gain insight of Anza and Beit Dajan farmers' perception on land application of sewage sludge for agricultural production; and (b) to investigate the determining factors whether or not to use sewage sludge for agricultural practices. This study is motivated by the recent construction of two WWTPs in the vicinity of Anza and Beit Dajan, West Bank.

Study area

The present study focuses on the rural communities of Anza and Beit Dajan in the West Bank. Inhabitants of these two villages rely heavily on agriculture for living. According to the Palestinian Water Authority (2009) report, the total estimated volume of wastewater generated was approximately 50 million cubic meters (MCM) in the West Bank, and 39 MCM in Israeli settlements and industrial zones. The wastewater network serves 35% of the West Bank population. For the year 2015, out of 524 localities in the West Bank, 80 localities had sewage networks, 456 had porous cesspits, and 181 had tight cesspit or septic tanks. Therefore, porous cesspits are still the most widespread collection method in the West Bank. The percentages of households served by the collection network in different areas of the West Bank approximately were 34% in the Northern part, 36% in the Southern part, and 48% in the Middle part (Applied Research Institute–Jerusalem 2015).

In the West Bank, approximately 67% of the wastewater collected by sewage networks is discharged into wastewater treatment facilities. The collected wastewater is treated or partially treated in 6 centralized wastewater treatment plants and in 16 collective wastewater treatment plants (Applied Research Institute–Jerusalem 2015). There are 5 relatively large WWTPs, 13 smaller facilities, and more than 700 small onsite treatment systems such as cesspits, with a total minimum capacity of 51,250 m^3/day. The Nablus plant, Jenin plant, Al-Bireh plant, Ramallah plant, and Tulkarem pretreatment plant are large capacity wastewater treatment facilities. Among these facilities, the Al-Bireh plant is the only properly functioning WWTP, producing approximately

Fig. 1 Map of Nablus and Jenin in Palestinian Authority (Palestinian Central Bureau of Statistics 2009)

21,000 m^3 of liquid sludge, equivalent to 550 m^3 of dry sludge per annum.

Since 1999, significant progress has been made in the level of sewer connections in Palestine. The sewage connection to households increased from 39.3% in 1999 to 52.1% in 2009 and to 53.9% in 2015, resulting in 15% increase of sewer connections for the last 16 years (Applied Research Institute–Jerusalem 2015). It is expected that more wastewater will be collected and treated by WWTP in the future, resulting in significant increase in treated wastewater and sludge for agricultural applications.

The village Anza

The village of Anza (population of approximately 2500) is located 26 km from the city of Nablus, 17 km from the city of Jenin, Jenin Governorate in northern West Bank, at an altitude of 410 m above sea level (Fig. 2). The total area of Anza is approximately 47,400 ha (4740 dunums) (Arafat 2013). Anza is known for cultivation of olive trees, almond trees, and rain-fed summer and winter crops. The village of Anza receives drinking water from a groundwater well (i.e., Jaba' well) through a water distribution network. The Jaba' well provides

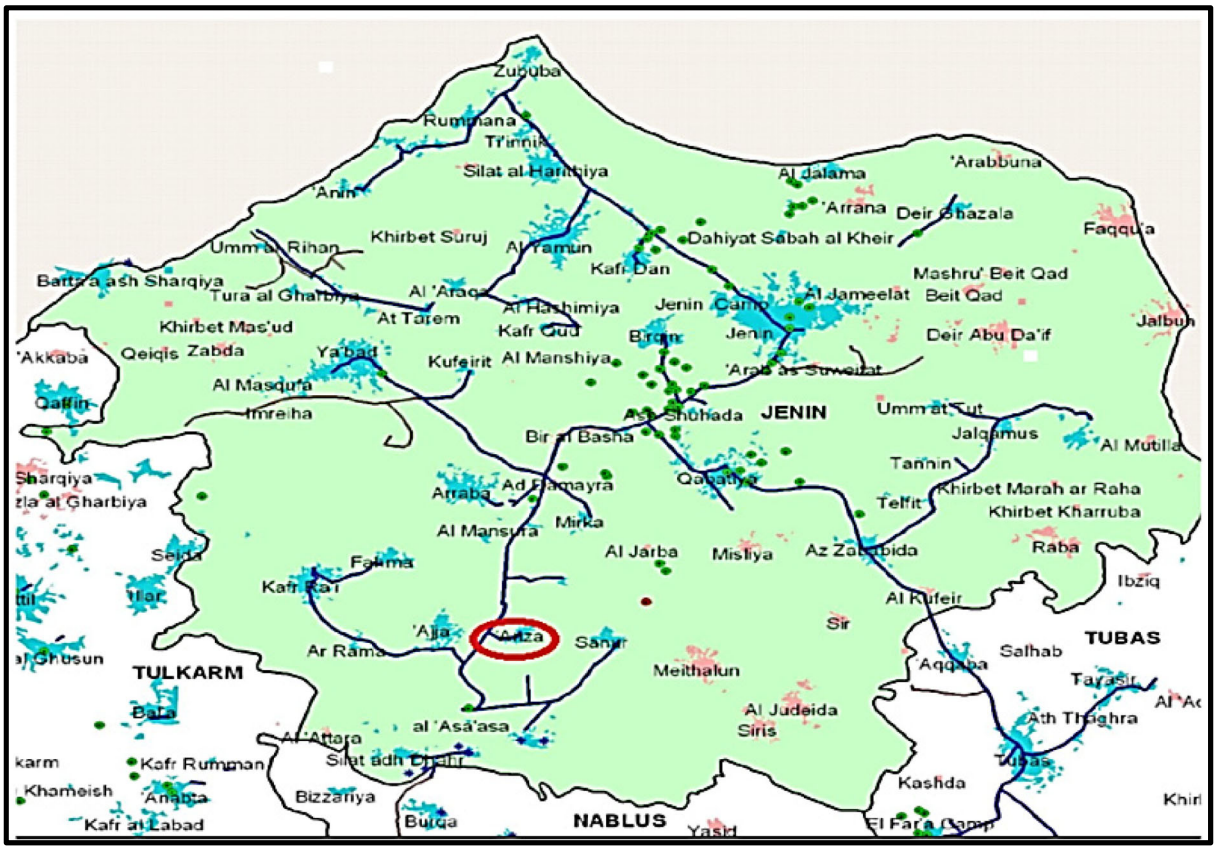

Fig. 2 Location of village Anza in the West Bank

approximately 4000 to 5000 m^3 of water per month. An average consumption of water is about 89 l per capita per day (Arafat 2013). The inhabitants of Anza are currently using a sewerage network system to dispose of wastewater. Based on the village's population and average water consumption, estimated wastewater generation rates are 135 and 380 m^3/day in years 2010 and 2035, respectively (Arafat 2013).

The village of Beit Dajan

The village of Beit Dajan (population of approximately 3589) is located 10 km east of Nablus (Fig. 3) (Palestinian Central Bureau of Statistics 2009). The village receives drinking water from a groundwater well (Beit Dajan well) through a water distribution network. An average consumption of water is approximately 66 l per capita per day (Arafat 2013). Beit Dajan inhabitants rely on rainwater and nearby springs for drinking and irrigation water supplies and use a recently established sewerage system for the disposal of wastewater. Based on its population and average water consumption, the wastewater generation was estimated to be 218 and 665 m^3/day in years 2010 and 2035, respectively (Arafat 2013).

Applied Research Institute–Jerusalem (2015) provided estimates of wastewater generation in Jenin and Nablus districts where the villages of Anza and Beit Dajan are located. In 2015, wastewater volume generated was estimated to be 65.8 MCM/year and sewage collection served 38.4% of the households in the West Bank. In the Jenin and Nablus districts, wastewater volumes generated were 4.9 and 9.2 MCM/year, respectively.

In Anza and Beit Dajan, there are recently established WWTPs and wastewater is currently treated by treatment plants that are recently established. The characteristics of sludge in these two villages are unknown. The most relevant work found was a study by Nassar and Afifi (2006) who describe wastewater volume and characteristics of the Gaza Strip. According to this study, it is estimated that approximately 3716 m^3/day of dry sludge will be generated in the Gaza Strip by year 2025. The

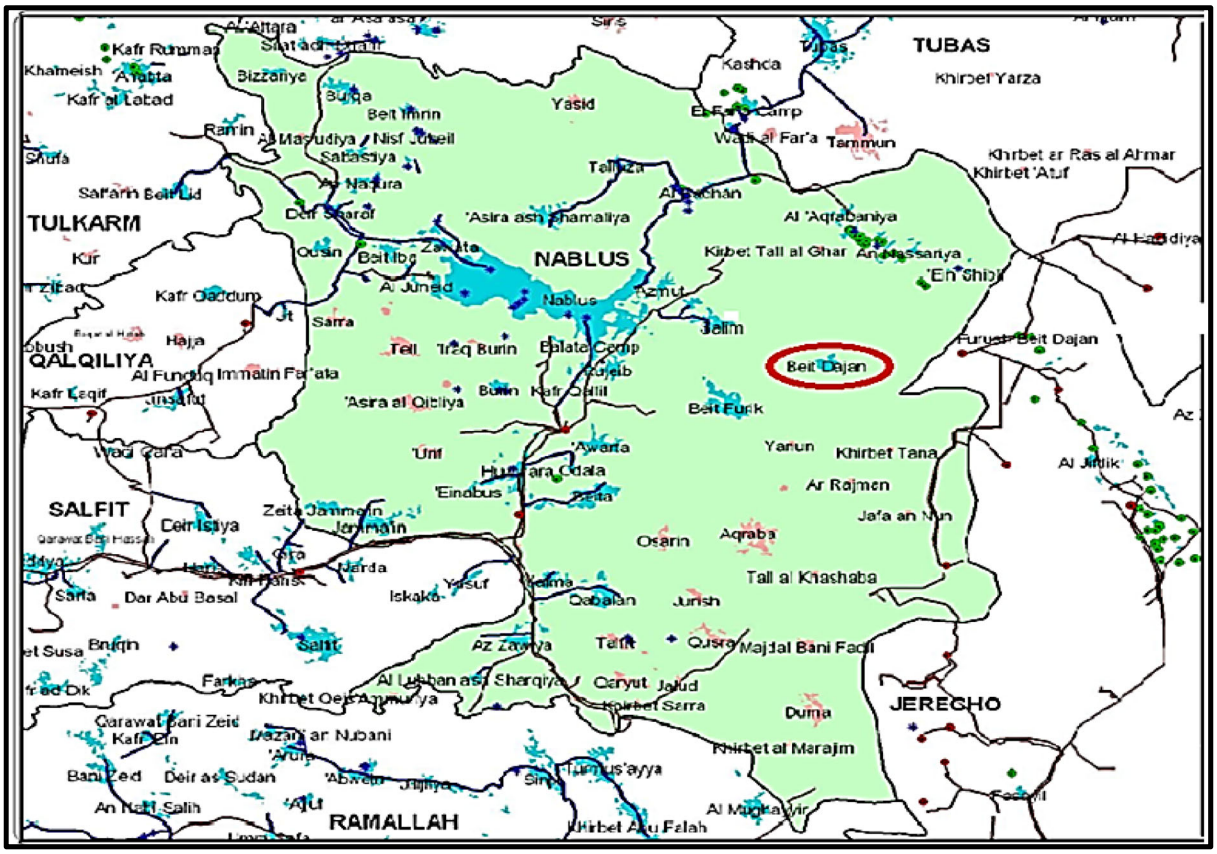

Fig. 3 Location of village Beit Dajan in the West Bank

sludge is expected to contain 1–2% dry solids, nearly free of heavy metals, and rich in nutrients (nitrogen and phosphorus).

Research methodology

In this study, a social survey in a form of interview was conducted, and a sample of 41 farmers from Anza and 65 farmers from Beit Dajan were randomly selected. The questionnaire consisted of a mix of structured and open-ended questions, and supplemental questions including farmers' age, location of residence, educational level, size of cultivated area for different crops, and a quantity and type of fertilizer used for different crops. The survey was given to the farmers using their language in Arabic. The surveyors were educated about sludge, its application methods, and the environmental, economic, and agriculture values that sludge provides. Collected data was analyzed using Statistical Package for Social Science software, (SPSS, version 17).

Results and discussions

Type of farmers, crop types, and types of fertilizers used

Among 106 farmers who participated in this survey, about 90% are male and 10% are female. In terms of age groups, 33% are between 31 and 40 years old, 25% between 20 and 30 years old, 21% between 41 and 50 years old, and 21% over 50 years old. The study by Krogmann et al. (2000) revealed that most of the farmers were males between the ages of 40 and 59.

Nassar et al. (2009) defined farm size as small, medium, and large for the farm less than 1 ha (10 dunums), between 1 and 3 ha (10–30 dunums), and larger than 3 ha (>30 dunums), respectively. Based on the classification by Nassar et al. (2009), a large fraction (73%) of the farmers in Anza and Beit Dajan own a small farm. In contrast, Nassar et al. (2009) reported that 27% of Gaza farmers owned a small farm. In terms of agricultural products, wheat is the most common crop (67%), followed by vegetable (9%), barley (3%), and other crops (21%), and that 84% of crops are rain fed, 3%

Table 1 Opinions on sewage sludge by farmers in Anza and Beit Dajan, West Bank

Survey question	Answer and percentage of respondents	
Q1. Do you accept the idea to build a WWTP	Yes	96%
	No	4%
Q2. Do you know the meaning of sewage sludge	Yes	83%
	No	17%
Q3. Do you know that sludge has benefits to soil and for agriculture uses	Yes	84%
	No	16%
Q4. Do you agree to use sludge for agriculture	Yes	82%
	No	12%
Q5. Is sludge a disgusting material	Yes	42%
	No	58%

are irrigated, and the remaining 13% are both rain fed and irrigated. Approximately 70% of the farmers self-consume their crops, while 30% sell their crops in markets. In a study by Krogmann et al. (2000), farmers owned or farmed from 1 to 1500 acres and generally had farmed for more than 25 years.

With respect to fertilizer type, 92% of the farmers use organic fertilizers and 8% use chemical fertilizers. These results are consistent with the previous finding by Nassar et al. (2009) who reported that the majority of Gaza farmers used organic fertilizers.

Farmers' overall response to the survey questions

Farmers in Anza and Beit Dajan were surveyed on their knowledge of sewage sludge and benefits of sludge. Further, they were asked their opinion about the planned WWTP that would produce a substantial amount of sludge. Results presented in Table 1 indicate that 96% of the farmers support the WWTP construction plan, and 83% are familiar with the meaning of sewage sludge. These results concur with the findings by Krogmann et al. (2000). In their study in New Jersey, USA, most of the vegetable farmers surveyed had knowledge of sewage sludge, had some college education, and were familiar with land application of sludge. Additionally, 60% of the farmers knew little to nothing about land application, 30% knew something, and only 8% of the farmers said they knew a great deal. None considered himself to be an expert.

In the present study, approximately 84% of the farmers knew that sludge provides benefits to soil, and 82% supported the use of sludge for agriculture purposes. More importantly, 58% of the farmers did not consider sludge as disgusting material. Overall, farmers' responses to the land application of sewage sludge are positive.

Aim for land application of sludge

In the survey on the aim of the use of sewage sludge in agriculture, the farmers' opinions vary (Fig. 4): 35% of the farmers responded that the aim should be to protect economic interests, 13% protect the environment, 7% avoid health, and 45% protect all of the above interests (i.e., protecting economic interest, environment and human health interests). None of the farmers replied that sludge has no purpose in agriculture.

Disadvantages of sewage sludge application

The issues of using sludge are deep-rooted, primarily due to its heterogeneous nature; that is, sludge contains

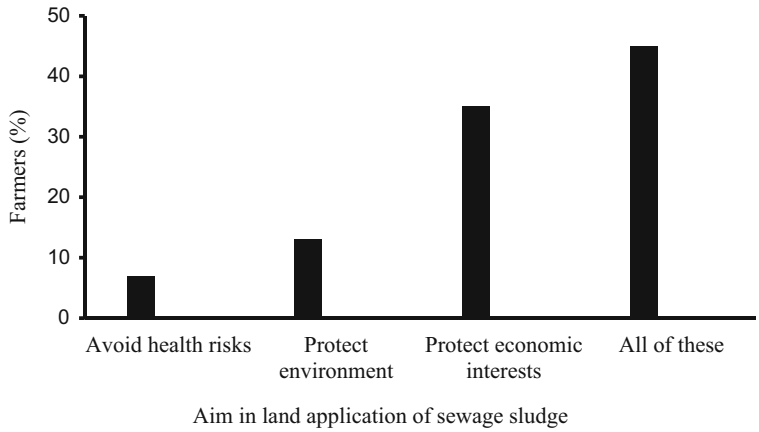

Fig. 4 Major aims in sewage sludge application identified by Anza and Beit Dajan farmers in the West Bank

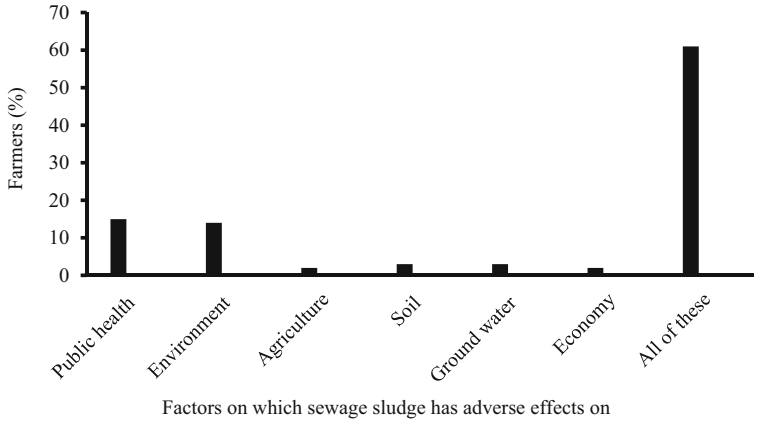

Fig. 5 Major disadvantages of sewage sludge application identified by Anza and Beit Dajan farmers in the West Bank

various amounts of toxic metals and organic compounds, salts, and pathogens. The anticipated drawbacks are the adverse effects resulting from the interaction of these constituents, long-term buildup of these constituents in soils, leaching of these constituents into waterways, and uptake of these constituents by crops and passed into food supply systems.

When Anza and Beit Dajan farmers were asked about the disadvantages of sludge use, they pointed out the following six factors: environment, soil, groundwater, economy, public health, and agriculture. The disadvantages associated with the public health, environment, and agriculture were indicated by 15, 14, and 2% of the farmers, respectively. Sixty-one percent (61%) of the farmers replied that land application of sludge adversely affects all of these factors (Fig. 5). Other adverse factors were chosen by small fractions of the farmers, i.e., 2% agriculture and economy, and 3% soil and groundwater. In comparison, farmers in New Jersey were concerned about their crop and their land, but not the environment (Krogmann et al. 2000). Our survey indicated that the majority of the Anza and Beit Dajan farmers do not have negative views on the land application of sludge. In the authors' opinion, intensive education efforts should be made to address the public health and environmental aspects of sewage sludge for promoting the land application practices.

Farmers' willingness to use sewage sludge for agriculture

In terms of the factors that would affect farmers' decision whether or not they use sewage sludge on their farm (Fig. 6), 38% of the farmers chose the "public acceptance to buy crops fertilized by sludge," 22% choose "price of sludge," 16% choose "public health risks," and 4% choose "religious reasons." The results revealed that the legality of sludge application was not of their major concern. Though the presence of laws and guidelines could provide farmers the confidence and psychological comforting sludge application, there are no such laws or formal guidelines in the West Bank. Perhaps, in the absence of such laws, legality was not the farmers' primary concern.

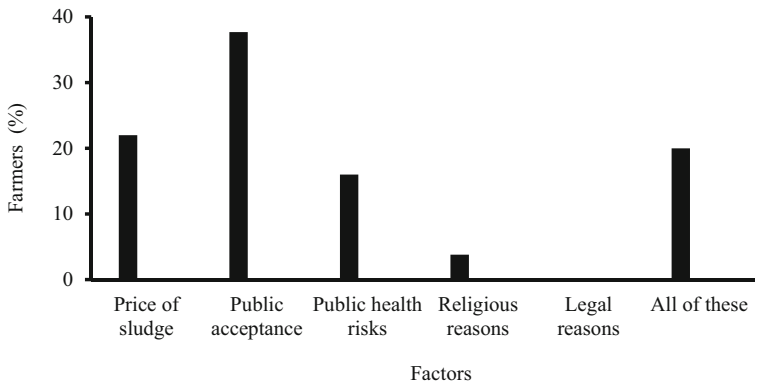

Fig. 6 Factors that affect farmers' willingness to use sludge for agriculture by Anza and Beit Dajan farmers in the West Bank

Table 2 Factors for not using sewage sludge for agriculture by the Anza and Beit Dajan farmers in the West Bank

Factors for not using sludge	Percent of farmers who rejected using sludge	Percent of total farmers
Psychological	20	5
Social	4	1
Public health	32	8
Religious	4	1
Perception of sludge as being unclean	12	3
Cheating oneself and others	8	2
All of these	20	5
Total farmers who rejected using sludge	100	24
Total farmers who accepted using sludge	–	76
Total farmers	–	100

The remaining 20% of the farmers indicated that all of these aforementioned five factors affect their decision (Fig. 6).

Farmers' opinions of using sludge from proposed wastewater treatment plant

At present, treated sewage sludge is not available for farmers in Anza and Beit Dajan because the WWTP has not yet been constructed. For this reason, farmers were asked a hypothetical question whether or not they would use treated sludge if sludge will become available in the future. The farmers' responses are presented in Table 2. Among 106 farmers, 81 farmers (76%) responded that they accept the land application of sludge, while 25 farmers (24%) reject the use of sludge. The farmers who accept the use of sludge intend to use it for fertilizing fruit trees rather than growing vegetables or other plants in a greenhouse.

Olive trees, figs, grapevines, almonds, and citrus are the major types of fruit trees planted in the West Bank. For fruit trees, farmers are likely to use sludge once every 2 to 3 years as they typically apply organic fertilizers at this frequency. For vegetables and field crops, the organic fertilizers are applied at each growing season (Nassar et al. 2009). In addition, for fruit trees the sludge will be far away from the fruit, while for vegetables the sludge will be nearer the fruit.

The results also show that these farmers prefer to sell their crops that were grown using sludge at the main vegetable markets rather than at the markets within their own village or in their vicinity. Twenty farmers (24%) rejected to use sludge for land application. They provided the following reasons of their rejection: psychological, social, public health, religious, perception of sludge as being unclean, perception of using sludge as cheating themselves and others, and combination of all of these factors. Among those who rejected the sludge use, 32%

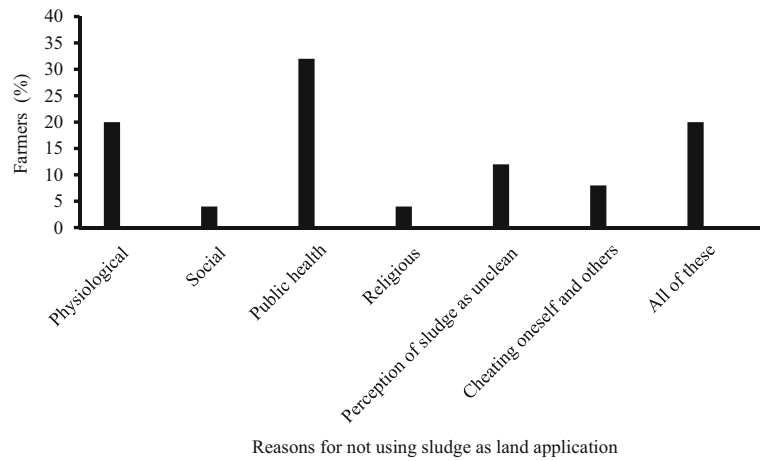

Fig. 7 Factors that trigger farmers not using sewage sludge for agriculture by Anza and Beit Dajan farmers in the West Bank

Table 3 Reasons for not consuming crops that are fertilized with sewage sludge by the Anza and Beit Dajan farmers in the West Bank

Reasons for not consuming crops that are fertilized with sewage sludge	Percent of farmers rejected consuming crops fertilized with sewage sludge	Percent of total farmers
Psychological	33	8
Social	8	2
Public health	29	7
Religious reasons	8	2
All of above	21	5
Total	–	23
Total farmers who accepted consuming crops fertilized with sewage sludge	–	77
Total farmers	–	100

indicated the public health factor as the main reason and 20% the psychological factor. These results are similar to those found in a study by Yassin and Abd Rabou (2002). In their study, farmers had the following views against the use of untreated sludge: (a) sludge is considered spiritual pollutant—psychologically unacceptable; (b) sludge contains pathogens, attracts insects, and generates offensive odors; and (c) sludge eventually deteriorates and potentially kills crops. In the present study, among the farmers who rejected the use of sludge, 32% gave "public health" as the main reason, and 20% psychological reason. The perception of sewage sludge as unclean was given by only 12% of the farmers. The social and religious reasons were chosen by only 4% of the farmers. Approximately 20% of the farmers selected aforementioned all six reasons for rejecting land application (Table 2 and Fig. 7).

Islam is the religion of the majority of inhabitants in the West Bank. Given the emphasis that Islam, like other religions, places on cleanliness, there is also a persistent notion that wastewater application is forbidden in Islam. Though efforts have been made by religious scholars to make wastewater reuse permissible for all purposes, some farmers continue to consider treated sludge unclean (Farouki 1999; Al- Kharouf et al. 2008).

Farmers' willingness to consume crops grown with the aid of sewage sludge

In respect to the farmers' willingness to consume crops grown using treated sewage sludge, 82 of 106 farmers (77%) responded positively (willing), while 24 farmers (23%) responded negatively (unwilling). Among the farmers who are in disfavor of consuming crops fertilized with sewage sludge, 33% selected the psychological reason, 29% the public health reason, and 2% the social and religious reasons, and 5% all of the above four reasons (Table 3 and Fig. 8).

Krogmann et al. (2000) indicated that the farmers in their study were asked about their perceptions about land application of sewage sludge. Farmers' concerns about sewage sludge were particularly apparent in

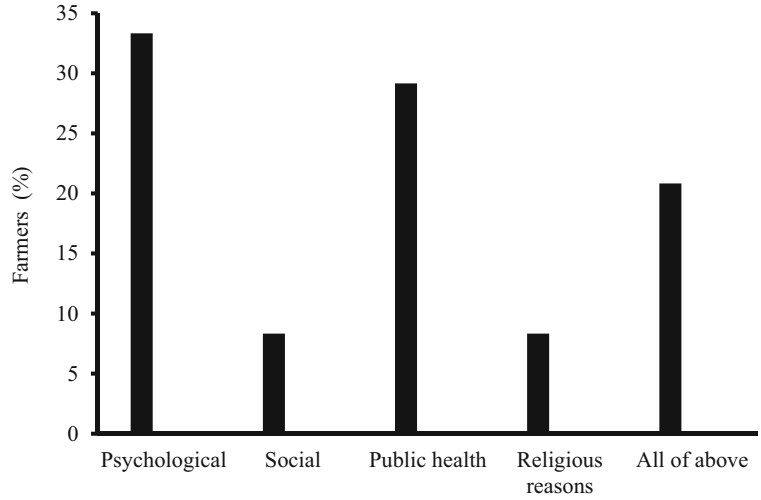

Fig. 8 Reasons for not consuming crops grown with sewage sludge by Anza and Beit Dajan farmers in the West Bank

response to their willingness to eat crops grown with the aid of sewage sludge. Among 50 farmers surveyed, 52% of the farmers were somewhat to very uncomfortable eating those food, while 17% were neutral, and 26% were somewhat comfortable or totally comfortable serving vegetables (harvested from the sludge applied land) to their families. No information was available for the remaining 2% of the farmers.

Summary and conclusions

This study is an effort to gain understanding of Anza and Beit Dajan farmers' perception on land application of treated sewage sludge. Surveys were conducted with randomly selected 106 farmers in the villages of Anza and Beit Dajan in the West Bank, Palestine territory. The survey questionnaire consisted of a mix of structured and open-ended questions. The recently established two WWTPs in the vicinity of Anza and Beit Dajan are expected to produce substantial quantities of sludge.

The survey results indicate that the majority of Anza and Beit Dajan farmers own a small farm with less than 1 ha, and that most farmers have knowledge of sewage sludge and the benefits it would provide to soil. They also have the knowledge that sludge could adversely affect soil, groundwater, human health, and the environment. Overall, farmers' perception on land application of sludge is positive, and majority of the farmers support the use of sludge when it becomes available in the future. The survey also revealed that farmers are in favor of using sludge for growing fruit trees rather than for growing vegetables and other plants in a greenhouse.

The major concern by Anza and Beit Dajan farmers are public perceptions, as their livelihood depends on consumers' satisfaction of their products. In this study, 45% of the farmers believe that land application should be carried out in such a manner that the environment and economic interests are protected and the health risks are avoided. Approximately 22% of the farmers believe that the price of sludge will affect their willingness to use sludge, and 38% public acceptance for buying crops fertilized by treated sewage sludge. Further, the results indicated that the opinions of farmers about land application can become more favorable if sludge is inexpensive, is safe to handle, and causes no human health effects. Despite the fact that a majority of the farmers view sludge as valuable material, some farmers have a negative perception of sludge. This study revealed that there is a need to educate farmers about the benefits of sludge and to improve farmers' perceptions on its land application.

Land application of sludge is a simple and cost-effective method; therefore, its application should be encouraged in the present and future wastewater treatment planning and management in Palestine. The findings from this study are valuable for Palestinian decision-makers in their roles to promote the use of sludge as fertilizers and soil conditioners. The Ministry of Agriculture and Extension Services should encourage farmers to use sludge generated in WWTPs of their community.

To promote land application of sludge, the following measures are recommended: (a) providing farmers access to information; (b) launching awareness programs to educate and train farmers for the safe and effective use of sludge; (c) raising public awareness by holding training workshops and conducting surveys about the efficient application of sludge; (d) continuing laboratory testing to identify possible impacts of sludge on their farm land and the environment; (e) conducting additional research addressing farmers' concerns about public perception, odors, etc., and communicating with farmers about the study results; and (f) improving enforcement if requested.

Currently, there is no regulation in Palestine allowing the use of sludge in agricultural practices. It is recommended that new laws or regulations should be developed to permit WWTP to produce sludge and allow farmers to use the treated sludge in agriculture.

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