

EFFECT OF THE NITROGEN FERTILIZER FACTORIES WASTES ON THE CONTENT OF NITRATE AND NITRITE IN THE EDIBLE PARTS OF SOME VEGETABLE CROPS, SOIL AND WATER

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ABSTRACT

A field survey study was conducted during the two successive winter seasons of 2016/2017 and 2017/2018 near the Factory of Nitrogen Fertilizers and Chemical Industries near Mansoura city, Dakahlia Governorate to investigate the effect of the factory wastes on nitrate and nitrite contents in the edible parts of some vegetables, soil and water. The experimental design was randomized complete block design (RCBD) with three replications. Samples of three vegetable crops; i.e.; potato, sweet pepper and watercress, soil and water were taken from both sides of the main drainage channel of wastes in three distances at (1, 3 and 5 km) from the factory, besides control treatment at the opposite direction from the factory.

The study revealed significant differences in (NO₃-) and (NO₂-) contents in the edible parts of vegetables, soil and water as follows:

The highest values of (NO₃-) in potato tubers contents were (16.65 and 15.72 ppm) and (NO₂-) were (0.477 and 0.500 ppm) at the highest distance (5 km) from the factory during the both seasons of study, respectively. In fruits of sweet paper, the highest contents of (NO₃-) were (39.19 and 36.45 ppm)

and (NO_2^-) were (1.223 and 1.457 ppm) at the longest distance (5 km) during the both seasons. The highest contents in leaves of watercress of (NO_3^-) were (77.46 and 81.32 ppm) and (NO_2^-) were (4.95 and 5.56 ppm) during the both seasons of study at the highest distance (5 km), respectively.

At the farthest distance from the factory (5 km), the highest contents in soil of (NO_3^-) were (12.62 and 12.75 ppm) and (NO_2^-) were (1.120 and 1.180 ppm) respectively, during the both seasons.

The highest contents of (NO_3^-) in water were (65.88 and 65.75 ppm) and (NO_2^-) were (2.687 and 2.727 ppm) at the intermediate distance (3 km) from the factory during the both seasons of study, respectively. While, the lowest contents of (NO_3^- and NO_2^-) in the edible parts (potato tubers, fruits of sweet paper, leaves of watercress), soil and water were obtained from the control treatment (the opposite direction of the pollution source) in both seasons.

INTRODUCTION

The pollution of air, soil, and plants specially fruits and vegetables become a common problem these days, and it happens due to the man made. The factories waste products are full of chemicals which lead to soil, water fruits and vegetables pollution.

Nitrate is a naturally occurring form of nitrogen and is an integral part of the nitrogen cycle in the environment. Concentrations of nitrates and nitrites in vegetables and other food products is an important quality indicator due to its influence on the human health. Nitrates itself is relatively low in toxicity, but it is degraded into much more toxic nitrites within the human body. Nitrite is ten times more toxic than nitrates (Cao *et al.*, 2016). The Environmental Protection Agency (EPA- 2012) has since adopted the 10 mg L^{-1} standard as the maximum contaminant level (MCL) for nitrate-nitrogen and 1 mg L^{-1} for nitrite-nitrogen for regulated public water systems.

Krupa (2003) reported that NH_3 is deposited rapidly within the first 4-5 km from its source. However, NH_3 is also converted in the atmosphere to fine NH_4^+ particle (ammonium) aerosols that are a regional scale problem. NH_3 uptake in higher plants occurs through the shoots, while NH_4^+ uptake occurs through the shoots, roots and through both pathways. However, NH_4^+ is immobile in the soil and is converted to NO_3^- (nitrate). In agricultural systems, additions of NO_3^- to the soil (initially as NH_3 or NH_4^+) and the consequent increases in the emissions of N_2O and leaching of NO_3^- into the ground and surface water are major environmental pollution.

Leake *et al.*(2009) documented that the risk of contaminants accumulating in air, soil, and water can influence the product quality, quality and healthiness. Uwah *et al.*(2009) indicated that nitrite content in the vegetables is usually very low compared to nitrate ,many vegetable crops accumulate high levels of nitrate. Leafy vegetables such as spinach, lettuce and celery contain nitrate at significant levels.

Chung *et al.*(2010) illustrated that nitrate contents in vegetables varied depending on the type of vegetables and were similar to those in vegetables grown in other countries. Matallana *et al.* (2010) found that nitrate levels were much higher in the leafy vegetables. Some vegetables (spinach, cabbage and eggplant) had lower nitrate content in the samples harvested in summer, showing the influence of climatic conditions on the nitrate levels in the plant. Tamme *et al.* (2010) reported that seasonal differences in nitrate concentrations were observed in lettuce and spinach. Nitrate concentrations in

lettuce were 22% and those in spinach were 24% higher in winter crops compared with samples collected in summer. Stephen *et al.* (2011) indicated that nitrate and nitrite concentrations for the different groups, in descending order, were leafy > root and tuber > fruiting and legume vegetables. On the other hand, nitrite concentrations were generally low -1 mg kg^{-1} on average. Kaymak (2013) stated that nitrate accumulation in leafy vegetables is harmful for human health, therefore, the usual dose of ammonium sulfate is firstly suggested that it should be applied to not only have better yield and agronomic traits, but also produce healthy crops for human nutrition. Maghanga *et al.* (2013) indicated that there was no established trend between surface water nitrate levels and the time of fertilizer wastes; however, fertilizer wastes contributed to an increase in nitrate levels. The initial nitrate-nitrogen levels in most of the rivers were high, indicating that contamination could have been upstream; however, the rivers should be monitored frequently.

Battilani *et al.* (2014) reported that the frequency of heavy metal and nitrate detection in potato tubers were comparable among water sources, as well as for the average contents. Cheng-Wei *et al.* (2014) stated that leafy vegetables (like lettuce) contain the highest nitrate levels and its classified as having very high nitrate content. Ziarati and Arbabi-Bidgoli (2014) stated that there is an inverse relationship between the nitrate content and crop size of onion, potatoes, beetroots, carrot, cabbage and lettuces. Large size onion, carrot, beetroot and potato had significantly lower nitrate levels than small

size. However, green leafy vegetables showed a positive correlation between the size and the nitrate content.

Ranasinghe and Marapana (2018) reported that nitrate is a major form that plants absorb nitrogen; vegetables can be considered as the main source of human nitrate intake. Nitrites also can be converted into N-nitroso compounds, which are known to be carcinogens.

This study aimed to investigate the contents of nitrate and nitrite in the edible parts of some vegetables (potato, sweet pepper and watercress), which product and consumed in the area near the Factory for Nitrogen Fertilizers and Chemical Industries near Mansoura city, Dakahlia Governorate.

MATERIALS AND METHODS

A field survey was conducted to investigate nitrate and nitrite contaminations in some vegetables, soil and water. The present study was carried out during the two successive winter seasons of 2016/2017 and 2017/2018 near the Factory for Nitrogen Fertilizers and Chemical Industries near Mansoura city, Dakahlia Governorate.

The experimental design was randomized complete block design (RCBD) with three replications. Where, samples of three vegetable crops i.e. potato (spunta var.), sweet pepper (california wonder var.) and watercress (common var.), soil and water were taken from both sides of the main drainage channel in three distances at (1, 3 and 5 km) from the source of contamination (Factory for Nitrogen and Chemical Industries near Mansoura city, Dakahlia

Governorate) besides control treatment (the opposite direction of the contamination source).

Recorded data:

Nitrate and nitrite determination methods in edible parts and leaves, soil

and water: The fresh random samples of edible part of the tested vegetables; i.e.; (potato tubers, sweet pepper fruits and watercress leaves) and leaves of (potato and sweet pepper) were collected at harvest from every distance and washed with deionized water. The samples of leaves, tubers and fruits were dried in an oven at 70°C until constant weight and digested by mixture of sulphoric and perchloric acids according to Peterburgski (1986).

The ash was dissolved in the minimum amount of HCl (1+1 v/v), distilled water (20 ml) was added and the mixture evaporated on steam-bath. Hydrochloric acid (20 ml 0.1 N) was added and the contents were heated for about 5 minutes, the solution was filtered through filter paper into a 100 ml volumetric flask. The filter paper was washed several times with HCL (5-10 ml, 0.1 N). The filtrate was cooled and diluted to volume with HCL (0.1 N).

Nitrate and nitrite concentrations were determined according to the methods described by Singh (1988).

All obtained data were subjected to the statistical analysis according to the technique of analysis of variance (ANOVA) for the complete randomized block design (CRBD) as published by Gomez and Gomez (1984) by means of MSTATE-C Computer Software. Least significant of difference (LSD)

method was used to test the differences between treatment means at 5 % level of probability as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

A- Potato: Means of nitrate (NO_3^-) and nitrite (NO_2^-) contents in potato tubers and leaves as affected by distances from source of the contamination during 2016/2017 and 2017/2018 seasons are presented in (Table 1).

Results in (Table 1) revealed that the distances from source of the contamination significantly affected nitrate (NO_3^-) and nitrite (NO_2^-) contents in potato tubers and leaves in both seasons. The highest values of nitrates in leaves (83.75 and 82.46 ppm), and in tubers (16.65 and 15.72 ppm), while nitrites in leaves (15.46 and 15.72 ppm) and in tubers (0.477 and 0.500 ppm).

These values were obtained from the highest distances from source of the contamination (5 km) in the first and second seasons, respectively, followed by the intermediate distances (3 km) and then the least distances from source of the contamination (1 km) in both seasons. While, the lowest values of (NO_3^-) in leaves (19.19 and 17.73 ppm), and in tubers (6.06 and 6.49 ppm), while (NO_2^-) in leaves (1.58 and 1.42 ppm) and in tubers (0.247 and 0.217 ppm) were produced from control treatment (the opposite direction of source of contamination) in the first and second seasons, respectively.

These increases in nitrate (NO_3^-) and nitrite (NO_2^-) contents in tubers and leaves of potato at the highest distance from source of the contamination (5 km) may be due to increasing large amount of ammonia pollutants in air

from height of smokestack of the contamination source which led to increasing absorption of potato leaves from ammonia vapor and increasing the chance to falling of ammonia vapor in winter season on the far distances (5 and 3 km), in addition to wastewater of the factory saturated with ammonia from the source of on potato plants caused increasing of nitrate and nitrite in leaves and tubers.

Moreover, increasing the speed of saturated water (ammonia, nitrate and nitrite) flow in the main drainage channel from the contamination source, which gradually reduced by increasing the distance from the source of contamination

Table(1): Nitrate (NO_3^-) and nitrite (NO_2^-) contents in potato leaves and tubers as affected by distances from the source of pollution during 2015/2016 and 2016/2017 seasons.

Charact ers Distance	NO_3^- in potato leaves (ppm)		NO_3^- in potato tubers (ppm)		NO_2^- in potato leaves (ppm)		NO_2^- in potato tubers (ppm)	
	2016/20 17	2017/20 18	2016/20 17	2017/20 18	2016/20 17	2017/20 18	2016/20 17	2017/20 18
1 km	52.94	54.15	14.15	13.96	10.59	10.41	0.357	0.360
3 km	72.60	70.08	14.80	14.26	14.65	14.88	0.377	0.447
5 km	83.75	82.46	16.65	15.72	15.46	15.72	0.477	0.500
Control	19.19	17.73	6.06	6.49	1.58	1.42	0.247	0.217
F. test	*	*	*	*	*	*	*	*
LSD at 5 %	6.60	5.16	0.43	0.68	0.96	0.67	0.064	0.062

caused by obstacles in the waterway, and subsequently raise the level of ground water which led to increasing in nitrate and nitrite concentrations of potato tubers and leaves. These results were in accordance with those

obtained by Krupa (2003), Stephen *et al.* (2011), Battilani *et al.* (2014) and Ziarati and Arbabi-Bidgoli (2014).

B- Sweet pepper: Nitrate (NO_3^-) and nitrite (NO_2^-) contents in sweet pepper fruits and leaves as affected by distances from source of the pollution during 2016/2017 and 2017/2018 seasons are presented in (Table 2).

The obtained results in (Table 2) indicated that the distances from the pollution source (1,3 and 5 km) significantly affected in nitrate.

Table(2): Nitrate (NO_3^-) and nitrite (NO_2^-) contents in sweet pepper leaves and fruits as affected by distances from the source of pollution during 2015/2016 and 2016/2017 seasons.

Character Distance	NO_3^- in sweet pepper leaves (ppm)		NO_3^- in sweet pepper fruits (ppm)		NO_2^- in sweet pepper leaves (ppm)		NO_2^- in sweet pepper fruits (ppm)	
	2016/2 017	2017/2 018	2016/2 017	2017/2 018	2016/2 017	2017/2 018	2016/2 017	2017/2 018
1 km	20.80	21.18	30.83	30.54	1.417	1.587	1.063	1.327
3 km	22.66	22.61	32.50	31.29	1.517	1.600	1.107	1.377
5 km	26.45	24.36	39.19	36.45	1.783	1.827	1.223	1.457
Control	7.41	5.96	10.73	10.54	1.023	0.983	0.763	1.040
F. test	*	*	*	*	*	*	*	*
LSD at 5 %	2.55	2.08	3.47	2.84	0.180	0.115	0.120	0.141

(NO_3^-) and nitrite (NO_2^-) contents in green pepper fruits and leaves in both seasons. It could be noticed that the highest values of nitrate in leaves (26.45 and 24.36 ppm) and in fruits (39.19 and 36.45 ppm), also the contents of nitrite in leaves (1.783 and 1.827 ppm) and in fruits (1.223 and 1.457 ppm) of sweet sweet paper were obtained from the longest distances from the

source of contamination (5 km) in the first and second seasons, respectively, followed by the intermediate distances (3 km) from the contamination source and afterward the slightest distances from source the of pollution (1 km) regarding its effect on nitrate and nitrite contents in green pepper leaves and fruits in both seasons. While, the lowest values of (NO_3^-) in leaves (7.41 and 5.96 ppm) and in fruits (10.73 and 10.54 ppm), (NO_2^-) in leaves (1.023 and 0.983 ppm) and in fruits (0.763 and 1.040 ppm) of sweet paper were produced from control treatment (samples taken from the other direction of source of the contamination) in the first and second seasons, respectively. These increases in nitrate and nitrite in fruits and leaves of sweet paper due to far from the contamination source might be due to the same reasons mentioned and discussed in nitrate and nitrite contents in potato leaves and tubers. Chung *et al.* (2010) and Stephen *et al.* (2011) confirmed these results.

C- Watercress: The results showed significant differences in nitrate (NO_3^-) and nitrite (NO_2^-) contents in watercress leaves during both seasons of study.

The contents of nitrate (NO_3^-) and nitrite (NO_2^-) in watercress leaves as affected by the distances from source of the contamination during 2016/2017 and 2017/2018 seasons are reachable in (Table 3).

Table 3: Nitrate (NO₃⁻) and nitrite (NO₂⁻) contents in watercress leaves as affected by distances from the source of pollution during 2015/2016 and 2016/2017 seasons

Characters Distance	NO ₃ - in watercress leaves (ppm)		NO ₂ - in watercress leaves (ppm)	
	2016/2017	2017/2018	2016/2017	2017/2018
1 km	70.26	70.96	2.51	4.70
3 km	71.75	71.62	3.60	4.84
5 km	77.46	81.32	4.95	5.56
Control	16.06	17.14	1.92	1.14
F. test	*	*	*	*
LSD at 5 %	3.58	4.03	0.60	0.43

The highest values of nitrate in leaves (77.46 and 81.32 ppm) and nitrite in leaves (4.95 and 5.56 ppm) were obtained from the uppermost distance from the contamination source (5 km) in the first and second seasons, respectively, followed by the intermediate distances from the contamination source (3 km) and then the shortest distances from the contamination source (1 km) in both seasons. Whilst, the lowest values of (NO₃⁻) in watercress leaves (16.06 and 17.14 ppm) and (NO₂⁻) in leaves (1.92 and 1.14 ppm) were produced from control treatment (on the opposite direction of the contamination source) in the first and second seasons, respectively

These increases in nitrate and nitrite contents in watercress leaves due to the far away from the contamination source might be due to the same reasons mentioned and discussed in nitrate and nitrite contents in potato leaves and tubers. These results are similar with those obtained by Zhaohui and

Shengxiu (2004), Uwah *et al.* (2009) , Stephen *et al.* (2011) and Cheng-Wei *et al.* (2014).

D- Nitrate (NO_3^-) and nitrite (NO_2^-) contents in soil and water: The means of nitrate (NO_3^-) and nitrite (NO_2^-) contents in soil and water as affected by the distances from the source of contamination during 2016/2017 and 2017/2018 seasons are available in (Table 4).

The obtained results showed in (Table 4) point out that the distances from the source of contamination (1, 3 and 5 km) significantly affected the contents of nitrate (NO_3^-) and nitrite (NO_2^-) in soil in both seasons. It could be noticed that the highest values of (NO_3^-) in soil (12.62 and 12.75 ppm), and (NO_2^-) in soil (1.120 and 1.180 ppm) were obtained from the longest distance from the source of pollution (5 km) in the first and second seasons, respectively, followed by the midway distance (3 km) and afterward the shortest distance from the source of contamination (1 km) regarding its effect on nitrate and nitrite contents in soil in both seasons. The lowest values of (NO_3^-) in soil (7.06 and 7.24 ppm) and (NO_2^-) in soil (0.830 and 0.870 ppm) were produced from control treatment (the opposite direction of the contamination source) in the first and second seasons, respectively.

Table(4): Nitrate (NO_3^-) and nitrite (NO_2^-) contents in soil and water as affected by distances from the source of contamination during 2016/2017 and 2017/2018 seasons.

Charact ers Distance	NO_3^- in soil (ppm)		NO_2^- in soil (ppm)		NO_3^- in water (ppm)		NO_2^- in water (ppm)	
	2016/20 17	2017/20 18	2016/20 17	2017/20 18	2016/20 17	2017/20 18	2016/20 17	2017/20 18
1 km	7.88	7.84	0.940	0.970	73.19	72.63	3.003	3.130
3 km	9.85	10.05	1.080	1.070	65.88	65.75	2.687	2.727
5 km	12.62	12.75	1.120	1.180	56.91	54.41	2.597	2.253
Control	7.06	7.24	0.830	0.870	0.38	0.37	0.013	0.015
F. test	*	*	*	*	*	*	*	*
LSD at 5 %	0.88	0.76	0.065	0.077	4.29	3.43	0.339	0.307

Nitrate (NO_3^-) and nitrite (NO_2^-) contents increased in soil at the furthest distance from source of the contamination might be due to increasing the speed of saturated waste water with (ammonia, nitrate and nitrite) flow in the main drainage channel which gradually reduced with increasing the distance from the contamination source caused by obstacles in the waterway, and subsequently raise the level of ground water, which contains a large amount of pollutants such as nitrate and nitrite.

In the same table, the results indicated that the distances from source of the contamination (1, 3 and 5 km) significantly affected the contents of nitrate (NO_3^-) and nitrite (NO_2^-) in drainage water in both seasons of study. It could be noticed that the highest values of (NO_3^-) in waste water (73.19 and 72.63 ppm) and (NO_2^-) in waste water (3.003 and 3.130 ppm) were obtained from the uppermost distances from the source of contamination (1 km) in the first and second seasons, respectively. This distance followed by the intermediate

distances (3 km) and afterward the slightest distances from the source of contamination (5 km) regarding its effect on nitrate and nitrite contents in water in both seasons. While, the lowest values of (NO_3^-) in irrigation water (0.38 and 0.37 ppm) and (NO_2^-) in irrigation water as a control treatment (0.013 and 0.015 ppm) were produced from control treatment (irrigation water from the opposite direction of the pollution source) in the first and second seasons, respectively.

These increases in nitrate (NO_3^-) and nitrite (NO_2^-) in waste water in the nearest distance from source of the contamination might be due to increasing pollutants (ammonia, nitrate and nitrite) in irrigation water at (1 km and 3 km) distances from the contamination source as a result of a large amount of saturated water pollutants with nitrate (NO_3^-) and nitrite (NO_2^-). Additionally, increasing the speed of saturated waste water with (ammonia, nitrate and nitrite) flow in the main drainage channel which gradually reduced with increasing the distance from (3km) to (5 km) from the contamination source caused by obstacles in the waterway, in addition to volatilization of nitrate (NO_3^-) and nitrite (NO_2^-) from saturated waste water which contains a large amount from nitrate (NO_3^-) and nitrite (NO_2^-).

These results were in accordance with those obtained by Krupa (2003) and Maghanga *et al.* (2013).

CONCLUSION

Data obtained in this study, indicated that increasing the distance from the source of pollution (Factory for Nitrogen Fertilizers and Chemical Industries near Mansoura city, Dakahlia Governorate) up to 3-5 km, the contents of nitrate and nitrite in the edible parts of vegetables (potato tubers, green pepper fruits and watercress leaves) were increased. This effect may be fading by increasing the distance from the source of contamination.

Therefore, it could be recommended to cultivate the vegetables at a distance more than (5 km) from the sources of pollution and Prevent cultivation vegetables near or round of the different sources of pollution specially factories for nitrogen fertilizers production.

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تأثير مخلفات مصانع الأسمدة الأزوتية على محتوى النترايت والنيتريت في الأجزاء المأكولة لبعض محاصيل الخضر والتربة والمياه

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المستخلص

تم إجراء مسح حقل ميداني خلال موسمي الشتاء المتتاليين ٢٠١٦/٢٠١٧ و ٢٠١٧/٢٠١٨ بالقرب من مصنع لانتاج الأسمدة الأزوتية والصناعات الكيماوية القريبة من مدينة المنصورة ، محافظة الدقهلية لدراسة تأثير مخلفات المصنع على محتوى النترايت والنيترت في الأجزاء المأكولة لبعض محاصيل الخضر والتربة والمياه . كان التصميم التجريبي المستخدم هو تصميم القطاعات كاملة العشوائية (RCBD) في ثلاثة مكررات. حيث تم أخذ عينات من ثلاثة محاصيل خضر وهي البطاطس والفلل الأخضر والجرجير والتربة والمياه من على جانبي قناة الصرف الرئيسية وذلك على ثلاث مسافات في (١، ٣ و ٥ كم) من مصدر التلوث ، بالإضافة إلى معاملة المقارنة (عينات تم أخذها من على الاتجاه العكسي لمصدر التلوث).
أوضحت الدراسة وجود اختلافات معنوية في محتوى النيترايت و النيتريت في الأجزاء المأكولة للخضر وفي التربة والمياه كما يلي:

- أعلى قيم في محتوى درنات البطاطس من النيترايت كانت (١٦,٦٥ و ١٥,٧٢ جزء في المليون) ومن النيتريت كانت (٠,٤٧٧ و ٠,٥٠٠ جزء في المليون) وذلك عند أطول مسافة (٥ كم) من المصنع في كلا الموسمين على التوالي . في ثمار الفلفل الحلو، كان أعلى محتوى فيها من النيترايت (٣٩,١٩) و (٣٦,٤٥ جزء في المليون) وكان أعلى محتوى من النيتريت (١,٢٢٣ و ١,٤٥٧ جزء في المليون) وذلك عند أطول مسافة (٥ كم) من المصنع في كلا الموسمين . أعلى محتوى من النيترايت في أوراق الجرجير كانت (٧٧,٤٦ و ٨١,٣٢ جزء في المليون) وكانت أعلى محتوى من النيتريت (١,٢٢٣ و ١,٤٥٧ جزء في المليون) وذلك عند أطول مسافة (٥ كم) من المصنع في كلا الموسمين على التوالي . عند ابعاد مسافة من المصنع (٥ كم) كانت أعلى

محتويات التربة من النترات (١٢,٦٢ و ١٢,٧٥ جزء في المليون) ومن النيتريت كانت (١,١٢٠ و ١,١٨٠ جزء في المليون) وذلك في كلا الموسمين على التوالي .
كان اعلى محتوى من النترات في المياه (٦٥,٨٨ و ٦٥,٧٥ جزء في المليون) وكان اعلى محتوى من النيتريت (٢,٦٨٧ و ٢,٧٢٧ جزء في المليون) وذلك عند المسافه المتوسطة (٣ كم) من المصنع في كلا موسمي الدراسة على التوالي .
بينما كانت أدنى قيم لمحتوى النترات و النيتريت في الاجزاء المأكولة (درنات البطاطس وثمار الفلفل الأخضر وأوراق الجرجير) واوراق (البطاطس والفلفل الأخضر) والتربة والمياه من العينات المأخوذة من معاملة المقارنة (العينات المأخوذة من الاتجاه العكسي لمصدر التلوث) في كلا الموسمين.
الكلمات المفتاحية: التلوث ، مخلفات المصانع، مصدر التلوث، محتوى النترات والنيتريت، البطاطس، الفلفل الحلو، الجرجير