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EVALUATION OF HARMFUL EFFECT OF POLLUTION SOURCES ON SOILS AND PLANTS VIA N, P AND K CONCENTRATION STUDIES AT MIDDLE NORTH DELTA REGION

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ABSTRACT

Fourteen waste water samples (municipal, agricultural and/or industrial) were collected from the extreme parts of middle North Delta region at pump station where pumped their waste water to the Burullus lagoon, bottom sediment samples also taken at the same locations. Fourteen soil profiles also taken which irrigated with the waste water, plant samples which planted on these profiles were taken in April 2010.

Macronutrient analysis; (N, P and K) of soil profile samples in three layers; 0-30, 30-60 and 60 to water table in centimeter. Plants and bottom sediments were analyzed also. Nitrogenous analysis nitrite, nitrate, ammonia and total nitrogen were analyzed of waste water samples.

The obtained results show that:

- Content of N, P and K in soil profiles was higher at location No. 4 than other studied locations, where El-Nasr fertilizer factory discharge their effluent in El-Tawella drain. Nitrogen content was lower in location No. 5 where irrigated with drain No. 3 while the total content of P in profile No. 1 irrigated with drain No. 1. K content and available P were lower in profile No. 3 before El-Nasr Fertilizer Factory.
- Content of N, P and K in plants depend on the type of plant and kind of irrigation water source (agricultural, industrial and/or municipal).
- Bottom sediments content from of N, P and K were higher than the content of soil profiles which irrigated with the polluted water especially at El-Nasr fertilizer factory.
- Surface layer content of N, P and K and were the highest and decreased with soil depth.
- All values of ammonia were higher than the maximum recommended level of waste water (0.5 mg/L) as reported by EPA, 1983.
- El-Nasr fertilizer factory was the main source of pollution in the studied region.

Keywords: Agricultural, industrial, leaching, pollution, pump station

INTRODUCTION

Drainage is necessary for food and fiber production from poorly drained soils and throughout much of the world. Increased productivity from drained lands allows us to meet the ever increasing production demand associated with the growing world population. However, with the use of fertilizer and the application of animal and municipal wastes to agricultural lands, the need has never been higher to ensure that water is being protected (Poolec *et al*., 2010).

Nitrogen and phosphorus are the most important nutrients as a quantity use to agricultural production systems and contribute greatly to the economical viability, sustainability and improvement of cropping productivity across the world.

With stead increase in the use of N and P fertilizers, surface runoff from agricultural lands contributes significant amount of N and P to water resource, including rivers and lakes and results in an consecutively accelerates eutrophication, which causes increasing concerns relating to economy, environment, society and human health. To minimize the loss of nutrients from agricultural fields, best management practices have been developed and implemented. However, such management practices must be tested and evaluated for specific locations to determine their efficiency (Pingjin *et al*., 2010).

The use of fertilizers is an integral part of crop production in Egypt and else where as a result of its use crop quantity have improved tremendously in the past few decades, and the cost of food is less than it would have been otherwise. But, the question arises, wherever, about the considerable impacts, direct or indirect, on the environment (Ramadan *et al*. 1999).

One of the main objectives of field drainage is to promote favourable soil-water-air relations. It is also tends to increase the leaching of nutrients, particularly, nitrate, the formation which required aerated conditions and which is readily soluble and poorly adsorbed by the soil, (Richard *et al*. 1989). Nitrate losses by leaching from agricultural soils is concern both for economic use of fertilizer and for maintenancy of water quality. Fertilizer containing N are of major potential source of N reaching to the ground water.

Also, it is almost a quarter of century since the Aswan High Dam was constructed. One of the major side effects of the dam is that the soils of Egypt are no longer supplied with the Nile suspended materials which used to come with the flood each year. The annual load of this materials was estimated to range about 120 million tons which used to contain a considerable amount of K bearing minerals (Balba, 1979). Under this circumstances, in addition to the intensive cropping and improvement soil drainage conditions which may enhance K leaching out of soil profile, the potassium supplying power of the soils decreased.

On the other hand, phosphorus in the soils are insoluble that surface drainage water carry little or no PO_4-P (Biggar and Corey, 1969 and Poolec *et al*., 2010) reported that soluble P in the soil solution of surface soils seldom exceeds 0.2 ppm, usually ranging from 0.01 to 0.1 ppm. Most soils have a high sorption capacity of phosphate. If irrigation was contains appreciable amounts of PO_4-P, one ppm or more, the concentration in the drains water will likely be less than in irrigation water as a result of the fixation of P by soil.

From the above mention we can conclude that the losses of both nitrogen and potassium nutrients via drainage, by leaching in the drainage and ground water, among the different plant nutrients, are considered (problematic point to be solved).

The main objectives of this study are determination of the concentration and amount of macronutrients of N, P and K of soils which irrigated with the drainage water of pump station which pumped their water into Burullus lagoon. To find a new fertilization policy for North Delta soils. Maintenance of surface water quality from pollution with nitrate which found to cause dangerous disease to mankind especially cancer if it reaches above the critical limit (the critical limit of NO_3-N in human food is 45 mg/day and for drinking water is 10 ppm. (W.H.O. 1984). Increasing the national and farmer income by decreasing the costs of agricultural and production.

MATERIALS AND METHODS

Water, soils and bottom sediment sampling:

Waste water samples (municipal, agricultural and industrial) were collected from the extreme parts of middle North Delta region which suffering from the water shortage at the pump stations before pumped their waste waters to the Burullus lagoon as in Table (1) except three samples were taken from El-Tawella drain directly after El-Nasr fertilizer company (Talkha city), El-Zeet drain (El-Mahalla El-Kobra) and Ganag drain (Kafr El-Zaiyat factories) and one sample was taken from Al-Sahil canal (fresh water). The waste water of these samples irrigated the adjacent soils, so that, we taken 14 profiles (Table 2) at depths 0-30 cm, 30-60 cm and 60 to water table from these locations to study the macronutrient elements (N, P and K) in soil profiles. Also, we taken 14 bottom sediment samples (Table 1) from the waste water at the pump station to study the nitrogen compound (nitrite, nitrate, and ammonia) and total nitrogen in these waste water samples. The increase of NO_3 concentration in the surface water, which in return causes a dangerous problems to mankind health in the Egyptian national income.

Table 1: Locations of the studied waste water and bottom sediment samples

Sample No.	Location
1	Lower drain No. 1 at pump station No. 1
2	Drain No. 2 at pump station No. 2
3	El-Tawella drain at Urea Unit of El-Nasr Fertilizer Company, Talkha
4	El-Tawella drain at Ammonia Unit of El-Nasr Fertilizer Company, Talkha
5	Drain No. 3 at pump station No. 3
6	Drain No. 4 at pump station No. 4
7	Drain No. 6 at pump station No. 6
8	Ganag drain
9	Upper drain No. 8 at pump station
10	El-Mandora pump station
11	Pump station No. 11
12	Pump station of El-Zeiny
13	Pump station of lower drain No. 8
14	El-Sahil canal

Analytical methods:

- Total content of potassium and phosphorus in soils and sediments were extracted using aquaregia method according to Cottenie *et al*. (1982).
- Available phosphorus of soils and sediments was determined by extracting with 0.5 N sodium bicarbonate according to Olsen *et al*. (1954) and determined colorimetrically by ascorbic acid method according to Van Schouwonburg and Waling (1967).
- Total nitrogen of soils and sediments were determined by macro-kjeldahl method (Page, 1982).

- Total nitrogen in plants was determined by macrokjeldahl method (Page, 1982).
- Determination of the total phosphorus of plants (seeds and straw). The digested materials were diluted in measuring flasks and the phosphorus content (%) of samples was determined colormetrically according to the method described by Snell and Snell (1967).
- Determination of the total potassium using flame photometer according to the method described by Jackson (1958).
- Nitrate (NO_3) and ammonia (NH_4) ions were determined in the drainage water samples using selective ion electrodes (accument model 2 pH ion meter), Fisher Scientific.

Table 2: Location of the studied soil profiles

Profile No.	Water irrigation type	Location	Vegetation plants (cultivated)
1	Drainage water	Irrigated from lower drain No. 1 (Pump station No. 1)	Wheat – clover
2	Drainage water	Irrigated from drain No. 2 (pump station No. 2)	Clover
3	Drainage water	Before of El-Nasr Fertilizer Company	Clover – wheat
4	Drainage water	After El-Nasr Fertilizer Company	Sugar beet
5	Drainage water	Irrigation from drain No. 3 (pump station No. 3).	Clover
6	Drainage water	Irrigated from drain No. 4 (pump station No. 4)	Sugar beet – wheat – clover
7	Drainage water	Irrigated from El-Zeet drain after El-Mehalla El-Kobra factories.	Maize – clover
8	Drainage water	Irrigated from Ganag drain (after Kafr El-Zaiyat Company)	Clover
9	Drainage water	Irrigated from drain No. 8 (pump station) of upper drain No. 8.	Clover
10	Drainage water	Irrigated from El-Mandora pump station (drain No. 9).	Clover
11	Drainage water	Irrigated from drain No. 11 (pump station No. 11)	Cotton
12	Drainage water	Irrigated from drain El-Zeiny (pump station El-Zeiny)	Wheat
13	Drainage water	Irrigated from drain No. 8 (pump station No. 8 lower)	Okra – green pepper
14	Canal water	El-Sahil canal	Wheat – clover

RESULTS AND DISCUSSION

1. Macronutrient elements:

a. In soils:

Table (3) and Fig. (1) showed that the maximum total content of N in the surface layers of studied soil profiles were 339.64 followed by 182.61 ppm surface layer of profiles No. 4 & 7 which irrigated with drainage water at Tawella and El-Zeet drain (After Talkha and El-Mehalla El-Kobra Factories) while the minimum content was 60.22 ppm sub-surface layer of profile No. 5 which drainage water of irrigated with drain No. 3 at pump station No. 3. The same Table also, showed that, generally, N content decrease with soil depth.

Table 3: Concentration of macro-nutrients elements (N, P and K) in the studied soils.

Profile No.	Depth (cm)	Total N ppm	Total P ppm	Available P ppm	Total K ppm
1	0-30	158.95	136.70	19.80	7038.95
	30-60	127.27	94.10	11.55	6701.88
	60-90	98.99	55.20	7.80	5062.17
	> 2 m	101.74	42.60	7.20	6006.70
	Mean	121.74	82.15	11.59	6202.43
2	0-30	140.00	100.80	21.60	6066.70
	30-60	124.14	75.60	16.20	4246.70
	60-100	106.52	55.20	12.30	3391.30
	Mean	123.55	77.20	16.70	4568.23
3	0-30	134.04	60.40	6.60	2904.26
	30-60	101.03	50.80	4.50	964.95
	Mean	117.54	55.60	5.55	1934.61
4	0-30	339.64	237.82	27.30	8119.39
	30-60	180.65	100.80	22.80	2698.77
	>2 m	76.09	95.20	22.20	1182.78
	Mean	198.79	144.61	24.10	3999.71
5	0-30	150.20	124.08	24.30	1157.42
	30-60	90.32	92.92	21.00	1174.19
	60-90	60.22	87.50	19.80	970.97
	Mean	100.25	101.50	21.70	1100.86
6	0-30	176.84	124.08	21.30	1383.87
	30-60	165.59	50.40	19.80	1313.68
	60-190	147.37	67.80	17.40	985.26
	Mean	163.76	90.76	19.50	1227.60
7	0-30	182.61	107.10	20.40	3391.30
	30-60	182.61	95.23	19.80	3179.35
	60-190	176.84	94.50	19.80	3187.10
	Mean	180.69	99.94	20.00	3252.58
8	0-30	150.54	134.42	20.40	7800.00
	30-60	136.96	129.25	21.30	6782.61
	60-210	105.38	82.72	19.20	6189.13
	Mean	130.96	115.46	20.30	6923.91
9	0-30	180.65	125.20	21.30	1509.68
	30-60	167.39	122.68	19.80	2246.74
	60-100	136.96	78.90	12.30	1483.70
	Mean	161.67	108.93	17.80	1746.71
10	0-30	163.83	93.60	24.60	2489.36
	30-60	134.11	93.06	12.60	1991.49
	60-170	121.74	48.90	10.20	1300.00
	Mean	139.89	78.70	15.80	1926.95
11	0-30	180.65	88.20	11.40	5870.97
	30-60	150.54	88.20	10.20	4663.04
	60-110	119.15	56.70	9.00	1190.53
	Mean	150.11	77.70	10.20	3908.18
12	0-30	162.11	88.20	10.80	2096.53
	30-60	136.96	88.20	9.00	2034.78
	60-80	106.52	56.70	9.00	1452.13
	Mean	125.20	77.70	9.60	1861.15
13	0-30	163.83	137.80	10.20	3941.49
	30-60	134.04	125.20	9.60	3311.92
	60-90	106.52	122.68	8.70	3068.09
	Mean	134.80	128.56	9.50	3440.50
14	0-30	105.38	125.20	10.80	4105.00
	30-60	103.16	52.68	10.20	2697.00
	60-100	87.50	48.90	8.70	2640.36
	Mean	98.68	75.59	9.90	3147.54

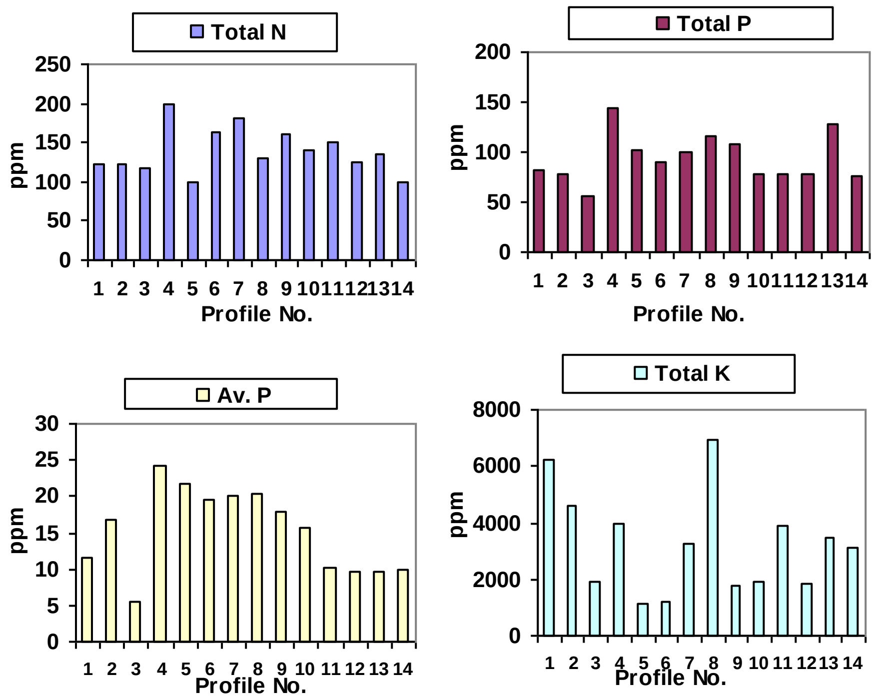

Fig. 1: Mean concentrations of macro-nutrients elements (N, P and K) in the studied soils.

The same Table revealed that the maximum total P content was 237.82 ppm in the surface layer of profile No. 4 after Talkha factory while the minimum content was 42.60 ppm in the sub-surface layer of profile No. 1 which irrigated with drainage water of the lower drain No. 1 at the pump station No. 1 and 48.9 ppm subsurface layer of profile No. (14) (canal water). Also, showed that the maximum available content of P was 27.30 ppm in surface layer of profile No. 4 while the minimum was 4.5 ppm in subsurface layer of profile No. 3 before El-Nasr fertilizer factory (Talkha). This trend illustrated the pollution effect of El-Nasr Fertilizer factory on El-Tawella drain.

Thomas *et al*. (1997) found that P leaching in drainage water could occur despite large adsorption potential of the soil. They attributed this to idea of (preferential flow of water flowing down large, possibly permanent cracks in the soil, thus reducing the effective sorption capacity of the Broadbalks sub soil). Bringing the drains close to the surface may increase the chance of preferential flow of phosphorus and possibly nitrogen in the sub soil.

Table (3) and Fig. (1) show that the maximum total K content was 8119.39 ppm in surface layer of profile No. 4 while the minimum content was 964 ppm in sub-surface layer of profile No. 3 like in this trend to total and available P and total nitrogen.

b. In plants:

Studies of macronutrient of plant in Table (4) showed that the values of N, P and K depend on the type of plant and the kind of irrigated pollution water which irrigated these plants, i.e. wheat in profile No. 1 grains and shoots were (2.74, 0.18, 2.700) & (1.540, 0.16, 1.650) % for N, P and K while profile No. 6 were (3.24, 0.26, 1.00) for grains and (1.84, 0.14, 0.10) for shoots. Profile No. 1 irrigated with lower drain No. 1 while profile No. 6 irrigated with drain No. 4.

Table 4:Macronutrient content (N, P and K) of vegetation plants (cultivated) in the studied soil profiles.

Profile No.	Plant species	Plant organ	N %	P %	K %
1	Wheat	Shoots	1.540	0.16	1.65
		Grains	2.740	0.18	2.70
	Clover	Shoots	3.180	0.13	2.19
2	Clover	Shoot	3.210	0.15	1.31
3	Clover	Shoot	3.220	0.14	1.10
4	Sugar beet	Roots	1.980	0.08	0.30
5	Clover	Shoots	2.940	0.11	1.20
6	Clover	Shoots	2.940	0.16	1.43
	Wheat	Shoot	1.840	0.14	0.10
	Wheat	grains	3.240	0.26	1.00
	Sugar beet	Roots	1.400	0.10	0.53
	Sugar beet	Shoots	2.940	0.12	2.00
7	Maize	Shoots	3.660	0.14	1.53
	clover	Shoots	3.220	0.16	0.90
8	Clover	Shoots	3.360	0.15	1.35
9	Clover	Shoots	3.080	0.12	2.16
10	Clover	Shoots	2.940	0.19	0.80
11	Cotton	Shoots	2.100	0.17	1.75
12	Wheat	Grains	3.640	0.13	0.83
	Wheat	Shoots	3.680	0.18	0.01
13	Okra	Shoots	3.200	0.14	2.10
	Green pepper	Shoots	3.920	0.15	1.80
14	Wheat	Grains	3.620	0.22	2.60
	Wheat	Shoots	2.800	0.20	2.60
	Clover	Shoots	1.360	0.10	1.30

c. In bottom sediments:

Table (5) revealed that the values of (N, P and K of the studied bottom) were higher than those studied in soil profiles, especially in location No. 3 & 4 at Talkha fertilizer Factory which discharge their effluents in El-Tawella drain.

2. Nitrogenous compounds (nitrite, nitrate, ammonia and total nitrogen).

Table 6 and Fig. 2 depicted nitrite, nitrate, ammonia and total N showed that nitrate content was higher than the ammonia content in all studied water samples except at locations No. 3 & No. 4. via versa where the Talkha fertilizer company discharge their effluents in El-Tawella drain.

Nitrate showed to be the largest concentration in locations No. 3 and 4 were 298.34 & 273.004 mg/L and the lowest level was 10.60 in location No.

14 (canal water). These results were in agreement with those obtained by Ibrahim *et al*. (2000).

The present observations were high than those recorded for El-Manzalah lake by Abdel-Hamid and El-Zareef, (1996) and Egyptian lakes such as Mariut, Edkuy and Burullus (Saad, 1990). This phenomena may be attributed to the effect of pollution and due to the difference between lakes and running water.

Nitrites are intermediate product in the nitrification processes of ammonia to nitrate (Abd El-Hamid and Zareef, 1996). The toxicity of nitrite may be due to the reaction of nitrite with secondary amines to produce carcinogenic nitrosamine that threated every vital tissue (Mostafa, 1988 and Ali, 1991).

Table 5: Concentration of macro-nutrients (N, P and K) in the studied sediment samples.

Sediment No.	N ppm	Total P ppm	Available P ppm	Total K ppm
1	165.59	75.60	10.20	3774.19
2	152.17	103.40	15.00	5850.00
3	306.32	206.80	25.80	6175.79
4	442.86	242.99	24.00	6622.65
5	195.70	47.88	17.40	1341.94
6	124.44	82.72	14.70	5416.67
7	195.70	111.67	15.60	4403.23
8	222.73	103.40	19.80	4121.59
9	121.74	37.80	10.20	1186.96
10	183.84	144.76	16.20	1181.82
11	136.96	107.21	14.70	1211.96
12	173.03	144.76	15.30	1971.91
13	159.09	72.38	7.80	3456.82
14	152.17	170.61	11.40	1483.70

Table 6: Nitrite, nitrate, ammonia and total nitrogen (mg/L) of studied water samples

No. of sample	Water irrigation type	Nitrite	Nitrate	Ammonia	Total
1	Drainage water	1.00	348.94	37.74	386.68
2	Drainage water	0.94	340.20	54.74	395.63
3	Drainage water	1.11	273.04	1288.4	1562.55
4	Drainage water	2.51	298.34	2654.76	2855.61
5	Drainage water	0.10	254.94	46.62	301.66
6	Drainage water	0.43	250.46	88.60	339.49
7	Drainage water	0.06	63.56	40.74	104.36
8	Drainage water	0.66	22.40	2.50	25.56
9	Drainage water	0.23	33.88	10.78	44.89
10	Drainage water	0.02	11.62	10.64	22.28
11	Drainage water	0.01	13.16	10.78	23.96
12	Drainage water	0.03	18.00	2.02	20.05
13	Drainage water	0.01	30.89	3.00	33.89
14	Canal water	0.01	10.60	0.20	10.81

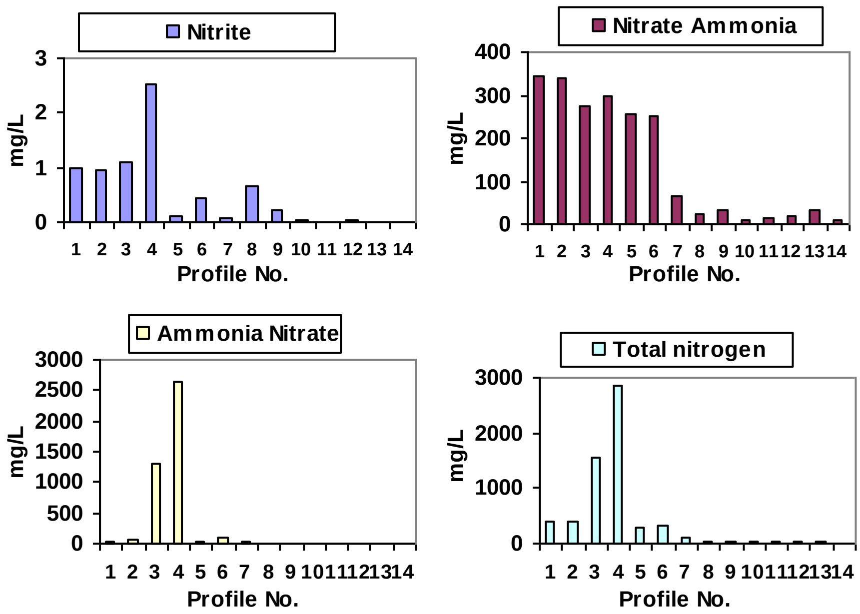

Fig. 2: Nitrite, nitrate, ammonia and total nitrogen (mg/L) of studied water samples.

Ammonia

Table 6 showed that the largest concentration in locations No. 3 & 4 (Talkha fertilizer factory) which were 1288.40 & 2654.76 mg/L, are considered to be toxic for plant and animals. The water in locations 3 and 4 sometimes showed that patches of ammonia floating over water surface due to high value of ammonia that produced from Talkha fertilizer factory.

All ammonia values obtained were higher than the maximum recommended level in waste water (0.5 mg/L are reported by EPA (1983).

Total nitrogen:

It could be observed from Table 6 and Fig. 2 that total nitrogen reached its recorded in maximum level at locations No. 3 & 4. The last location showed more concentration for all nitrogenous compounds as it products are nitrogenous fertilizers and soils discharge will increase nitrogen compounds.

Total nitrogen estimated showed to be more than nitrogen in different forms of compounds as nitrite, nitrate and ammonia. This may be as a result of different ways of stimulating nitrogen in the forms of nitrogenous compounds.

CONCLUSION

Use of low quantity water in irrigation could be an important consideration when the disposal is being planned in arid and semi-arid regions. The regions of study lies in middle North Delta region and suffer from the shortage of water and planted rice plant in summer season. Egypt, must be obligatory under taken for these factories to prevent them from polluting agricultural soil by waters. The drains of waste water could not use in irrigation till subject to secondary treatment, in order to notably decrease all quality characteristics. When this water quality be close to the international permissible levels, it becomes safe and applicable.

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تقييم التأثير الضار من المصادر الملوثة للأراضى والنبات فيما يتعلق بتركيزات النتروجين والفوسفور والبوتاسيوم وذلك بمنطقة شمال وسط الدلتا

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أجريت هذه الدراسة بهدف الوقوف على مستوى التغيير للعناصر الغذائية الكبرى فى الاراضى والنباتات ورواسب القيعان فى أقصى شمال وسط الدلتا وكذلك المركبات النتروجينية (النترات والنتريت والأمونيا) والنتروجين الكلى فى مياه المصارف قبل رفعها الى بحيرة البرلس ولتحقيق هذا الهدف أخذت 14 عينة مياه من المصارف قبل ضخها الى بحيرة البرلس مباشرة عند محطات الرفع وكذلك تم أخذ 14 قطاع أرضى ممثلين للأراضى التى تروى بهذه المياه الملوثة ودراسة مدى تأثيرها على محتويات الأراضى والنبات ورواسب القيعان من العناصر الغذائية الكبرى (NPK) وكذلك مدى سمية هذه المياه وذلك بتقدير المركبات النتروجينية (النترات ، النتريت ، الأمونيا) وأجريت التحليلات لهذه العينات ويمكن تلخيص النتائج المتحصل عليها كما يلى:

- محتوى الأرض المدروسة من العناصر الغذائية الكبرى (NPK) كان مرتفعا فى الموقع رقم (4) بعد مصنع سماد طلخا ومنخفضا عند الموقع رقم (3) قبل مصنع السماد ، وذلك بالنسبة للفوسفور الميسر والبوتاسيوم وبالنسبة للنتروجين كان منخفض عند الموقع رقم (5) حيث تروى من مصرف رقم (3) ، أما الفوسفور الكلى فكان منخفض عند القطاع رقم (1) حيث يروى من مصرف رقم (1) الاسفل.
- محتوى العناصر الغذائية الكبرى فى النباتات (NPK) يتوقف على نوع النبات المنزرع ونوع الماء الملوث المروى به وعمر النبات وقت أخذ العينة.
- العناصر الغذائية الكبرى (NPK) أعلى فى الطبقات السطحية ومنخفض فى الطبقات تحت السطحية.
- جميع قيم الامونيا كانت عالية جدا عن المستوى المسموح به
- مصنع السماد بطلخا هو المصدر الرئيسى لتلويث المجارى المائية فى هذه المنطقة التى يمر عليها مصرف الطويلة وفروعه.

قام بتحكيم البحث

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