The geostatistical analysis showed that three semi-variogram models fitted the individual soil properties. The fitted models were exponential for BTPA- Fe and Cl^-, spherical for DTPA- Zn , Mn & Ni and Na^+, while DTPA-Cu, Pb , EC and SAR were Gaussian. Semi-variogram model parameters showed that EC and heavy metals have the highest nugget variance, which indicated their strong spatial dependence and high inherited variability. The kriging map showed that the spatial and temporal variability of heavy metals in the studied area.

Keywords: Sewage waste water, Industrial waste water, Semi-variogram, Kriging and Spatial and Temporal variability.

The scarcity of freshwater for agriculture in the arid zone area is considered the most limiting factor in the coming twenty-one century for food production. So, many countries, including Egypt, started to look to wastewater reuse for irrigation and crop production in order to cover the shortage of freshwater and meet their demands for more food production,

The increased amounts of municipal and industrial wastewaters and its disposal are considered one of the most important problem around the world, The attempts to reuse those wastes as a source of irrigation and plant nutrients, particularly in the semi-arid and arid regions, have been reported (Day et al., 1981, Cambell et al., 1983 and Bieloria et al. 1984).

Rabie *et al.* (1996 a) studied the contents of Biogenic (Fe, Mn, Zn, and Cu) and non-Biogenic (Pb and Cd) heavy metals in El-Saff soils as related to different pollution sources (different industrial activities- sewage waste) as well as a virgin non-irrigated soils for comparison. They found that the highest content of the trace elements (Fe, Mn, Zn, Cu, Pb and Cd) in all sites was found in the surface layers of soils irrigated with polluted sources. The average content of total Fe, Mn, Zn, Cu, Pb and Cd in the surface layer of the soils irrigated with industrial wastes are 15.65 %, 2340 ppm, 399 ppm, 167 ppm, 129 ppm and 1.9 ppm, respectively. In soils, irrigated with sewage waste, the average content of these elements was 4.03 %, 514 ppm, 585 ppm, 252 ppm, 189 ppm and 3.3 ppm, respectively. The virgin non-irrigated soils on the other hand, contains 1.42%, 160 ppm, 28 ppm, 69 ppm, 65 ppm and 0.6 ppm of Fe, Mn, Cu, Pb and Cd, respectively.

Rabie et *al.* (1996 b) studied the distribution of different heavy metals in the different particle size fractions of soils irrigated with different industrial sewage wastes. They found that the highest values were found in clay fraction, while the lowest ones were found in sand fraction. In addition, all fractions of soils irrigated with industrial wastes have the highest amounts of Fe and Mn, while fractions of soils irrigated with sewage wastes have the highest amounts of Zn, Cu, Pb and Cd. Data showed that the enrichment of heavy metals in the clay fraction is about 33, 24, 14, 13, 12 and 10 times as compared to the sand fraction for Mn, Cu, Fe, Cd, **Zn,** and Pb, respectively. The degree of enrichment, on the other hand, varies between 1-1.5 times for the various metals in the silt fraction compared to sand fraction.

Elsokkary and Sharaf (1996) studied two cultivated regions representing alluvial and lacustrine soils. The source of water for irrigation in alluvial soils is a mixture of agricultural drainage and domestic effluents and that of lacustrine is a mixture of agricultural drainage, domestic and industrial effluents. The soils were enriched by Cd and to some extent by Zn. The amounts of DTPA-Zn and-Cd represented about 0.5 and 13% of the total in alluvial soil and about 0.8 and 13%of the total in soil of **lactustrine** soils, respectively.

Abdel-Sabour et al. (1996) investigated five heavy metals content namely Fe, Zn, Cu, Co and Pb in Cairo sewage effluent being used in irrigation of sandy soil of **El-Gabel** El-Asfar farm, It was noticed that total **Zn** in sewage sludge and sewage effluent were higher than the permissible doses agreed by the USA-EPA. Copper concentration was at the upper critical permissible dose. However, Pb was less than those reported by USA-EPA. They reported that large amounts of Fe, Zn, Cu and Pb accumulated over 52 years of irrigation with Cairo sewage effluent in the order: Fe **>Zn** >Pb **>Cu** >Co. **El-Gamal** (1980) reported that the average concentration of heavy metals in raw and final effluents from El-Cabal Asfer, were **0.01,0.04,0.63,0.15,** 0.10 and 0.15 ppm for Cd, Cu, Fe, Mn, Pb and Zn, respectively.

The objectives of the present work were to study the spatial and temporal soil variability under irrigation with the different treated wastewater and mixture of Nile water and agriculture drainage water on some soil physical and chemical properties.

Material and Methods

(a) *Field work*

A comparative study was undertaken to evaluate the safe use of the low quality water for irrigation at Sewage Waste Station Farm, New Burg El-Arab City, North West Coast, Egypt. The sources of irrigation water were sewage waste, industrial waste, mixture of Nile water with agriculture drainage water (Bahige canal) and rain fed. Soil samples were collected in March, 1999 from the surface (0-30 cm) and subsurface layers (30-60 cm) from different soil sites that were irrigated with treated sewage water for three different periods (2,3 and 6 years), industrial waste water (1 year), mixed water and rainfed. Also, Water samples were collected from the treated sewage waste basin, treated industrial waste basin, mixed water (Bahige irrigation canal) and rain water (Table 1). The studied soil is characterized by texture class of sandy loam (sand 59.5 %, silt 21.35% and clay 19.15%) and calcareous in nature (average total $CaCO_3$ 32.4%).

TABLE 1. Different sources of irrigation, total area feddan, number of soil observations and major cultivated crops.

Source of water	Abbreviation	Total area (feddan)	Number of soil observations	Major crops
Treated sewage waste (2 year)	Sw2	150	15	Grape and Mulberry
Treated sewage waste (3 year)	Sw3	40	5	Grape and Mulberry
Treated sewage waste (6 year)	Sw6	100	10	*Melia Azerachta* (Neem)
Treated industrial waste (1 year)	Inw	15	10	Uncultivated
Mixed water (Bahige canal)	Mw	10	10	wheat , tomato and egg plant
Rainfed	R	10	5	Wheat and barely
Total		315	55	

(b) *Laboratory analysis*

Water analysis

The average values of the major characteristics for the treated waste and mixed waters are given in Table 2. The effluent of wastewater contains moderate

1986). The semi-variance is defined as follows:

$$y(h) = 1/2\ Var\,[Z(x) - Z(x+h)]$$

where; Z(x) and **Z(x+h)** are the values of a random function representing the soil property of interest, Z at places x and **x+h** separated by vector h known as the lag and Vat is the variance.

The obtained semi-variance values for each lag were fitted to one of the semivariogram functions using the **GSPLUS** geostatistical analysis software, Gamma Design (1991). The semi-varigram model with its parameters is shown in Fig. 1, as an example of how these models and their parameters are illustrated on graphs.

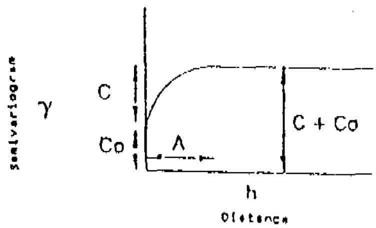

Fig.1. Typical variogram model and its parameters (adopted from Warrick *et al.*, 1986).

Y : the semi-varigram Co : the nugget variance
Co +C : the sill variance A : the lag distance
h : the lag distance

The nugget (Co) is the semi-variance values due to short scale or inherited variability; the range (A) is the distance at which the semi-variance reaches its maximum, after which there is no spatial dependence occur among the samples, and within it interpolatian is worth while; and (Co+C) is the plateau (constant value) that the semivarigram reaches (Issaks and Srivastava, 1989).

Kriging is a method of interpolation using the weighted local averaging. It is optimal in a sense that the weights are chosen to give unbiased estimates, while keeping the estimation variance at minimum (Webstcr, 1985). Kriging maps and three-dimensional (3D) were calculated and drown using software, Surfer (1994).

The trend of Pb followed: Inw > Sw6 > Sw3 > Sw2 > Mw> R. The highest values were 3.1 and 2.02 mg/kg in the surface and subsurface layers of soil irrigated with Inw. As for the different periods of application of Sw, its values were 1.84, 1.64 and 1.32 mg/kg for Sw2, Sw3 and Sw6 in the surface layer, respectively. Also, these values were 1.48, 1.5, and 1.06 mg/kg in the subsurface layer, respectively. In, Mw and R the values were 0.78, 0.7 and 0.5, 0.56 mg/kg in the surface and subsurface layers, respectively, (Table 7).

TABLE 7. DTPA extractable heavy metals of soil affected with the different water resources

Treatments	Depth (cm)	Pb	Ni	Fe	Zn	Mn	Cu
		(mg/kg)					
Sw2	0-30 3040	1.32 1.06	0.50 0.44	4.34 2.52	0.70 0.26	5.28 2.90	0.44 0.30
Sw3	0-30 30-60	1.64 1.50	0.62 0.60	6.80 4.38	0.80 0.32	7.18 3.08	0.50 0.34
Sw6	0-30 30-60	1.84 1.48	0.94 0.72	10.24 5.60	1.04 0.40	11.28 4.72	0.60 0.38
Inw	0-30 30-60	3.10 2.02	0.62 0.56	2.02 1.88	3.42 0.34	6.40 5.06	0.82 0.44
Mw	0-30 30-60	0.78 0.50	0 34 0.20	1.88 1.08	0.44 0.22	2.06 1.88	0.28 0.16
R	0-30 30-60	0.70 0.56	0.26 0.18	1.22 1.06	0.22 0.20	1.82 1.34	0.24 0.14

Sewage waste application caused remarkable increase of Ni-DTPA. The values were 0.94, 0.62, 0.5 mg/kg and 0.72, 0.6, 0.44 mg/kg in Sw2, Sw3, Sw6 in the surface and subsurface layers, respectively. In general, the trend of Ni followed the order of Sw6 > Sw3 = Inw> Sw2 > Mw > R, Table 7.

It can also be noticed that, the Sw application increased the Fe-DTPA after the periods of application 6, 3, and 2 years. The Fe values were 10.24, 6.8 & 4.34 and 5.6, 4.88 & 2.52 Ing/kg in the surface and subsurface layers, respectively. The data showed that Fe-DTPA in the Inw was low like Mw and R. Generally, the trend of Fe- DTPA followed the order of Sw6> Sw3 > Inw> 5w2 > Mw> R, (Table 7).

The amounts of Zn-DTPA in the soil irrigated with industrial wastewater were generally higher than there irrigated from sewage wastewater after different

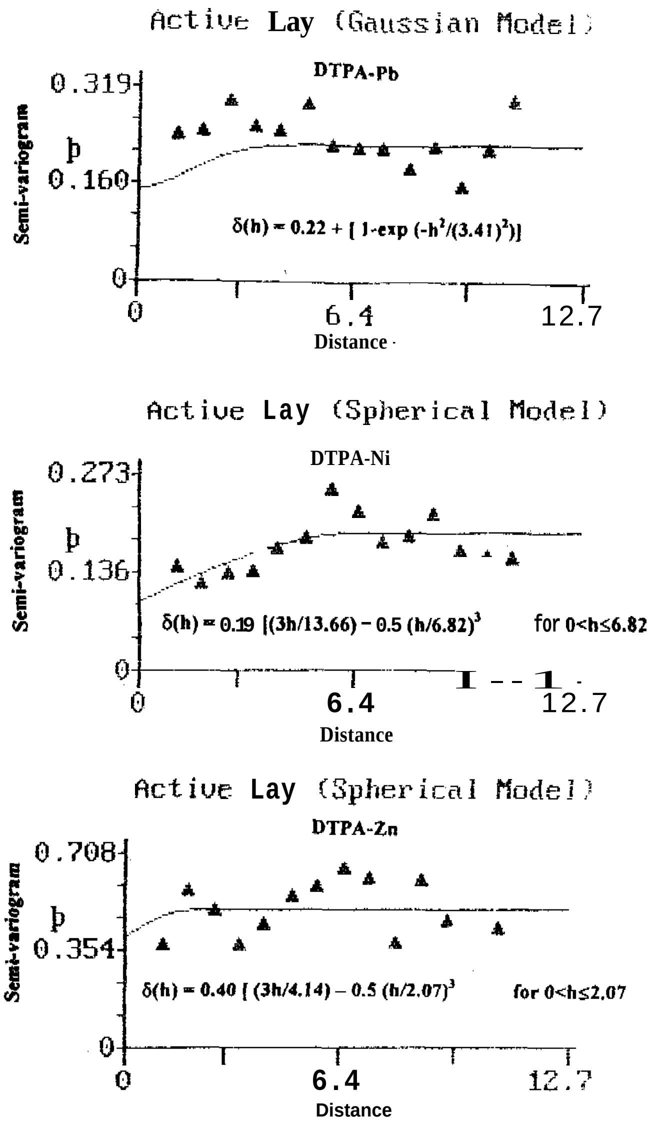

Fig. 2. Semi-varlogram models of DTPA-(Pb, Ni & Zn).

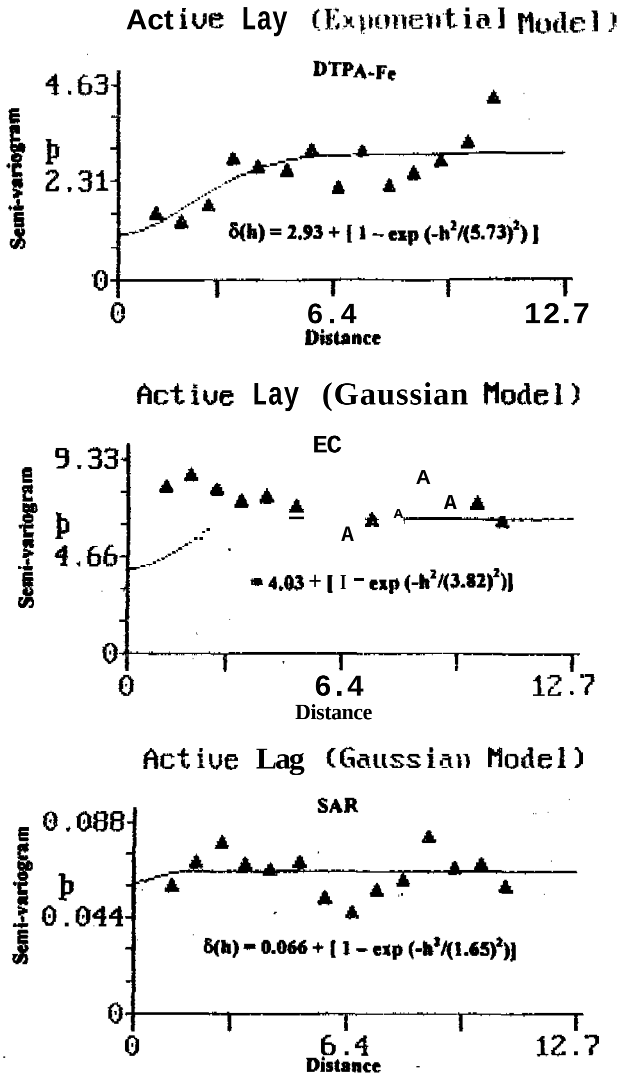

Fig. 3. Semi-variogram models of **DTPA- Fe,EC** and SAR.

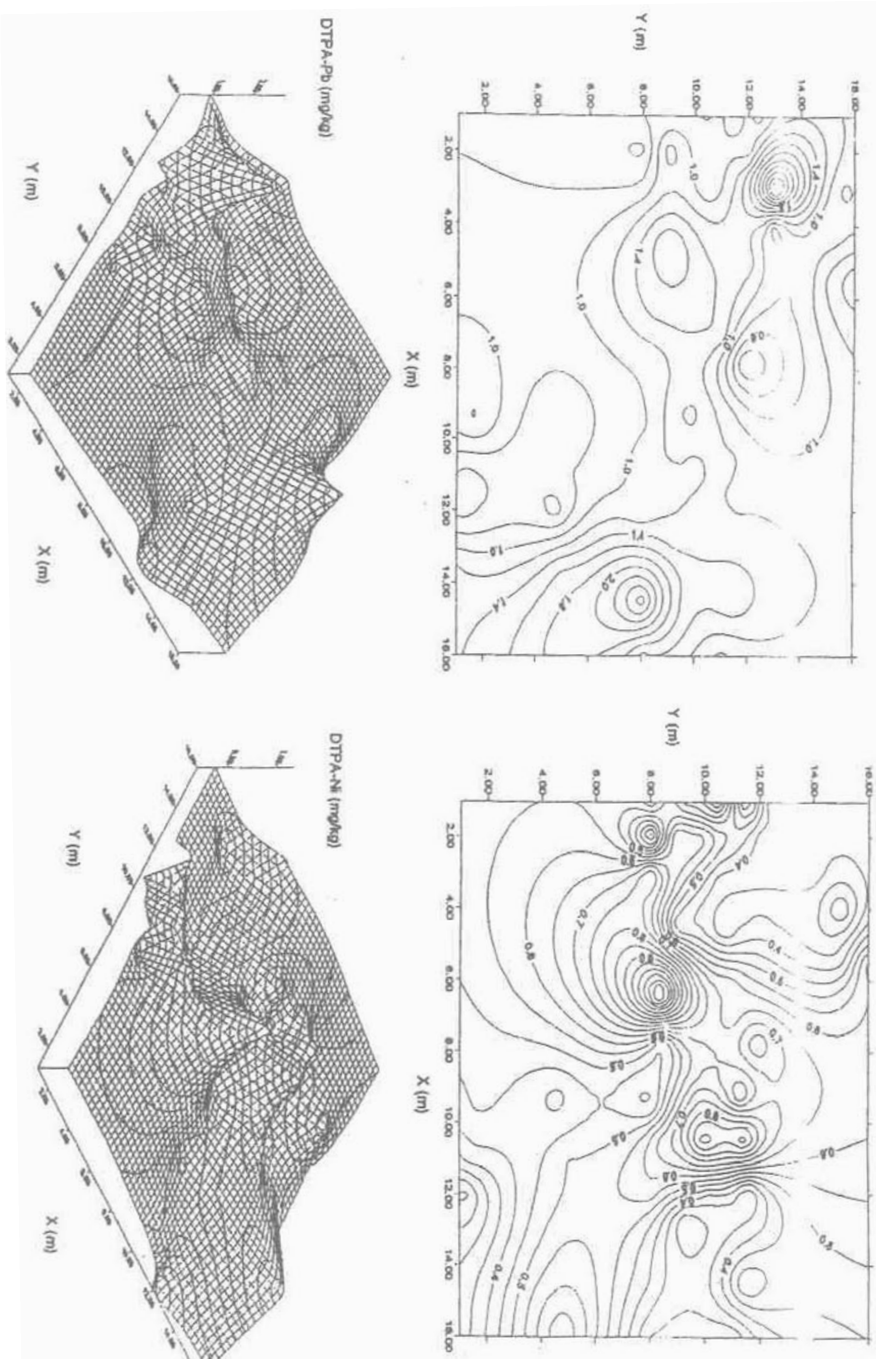

Fig. 4. Kriging map and 3 D of DTPA-Pb and Ni for the surface layer.

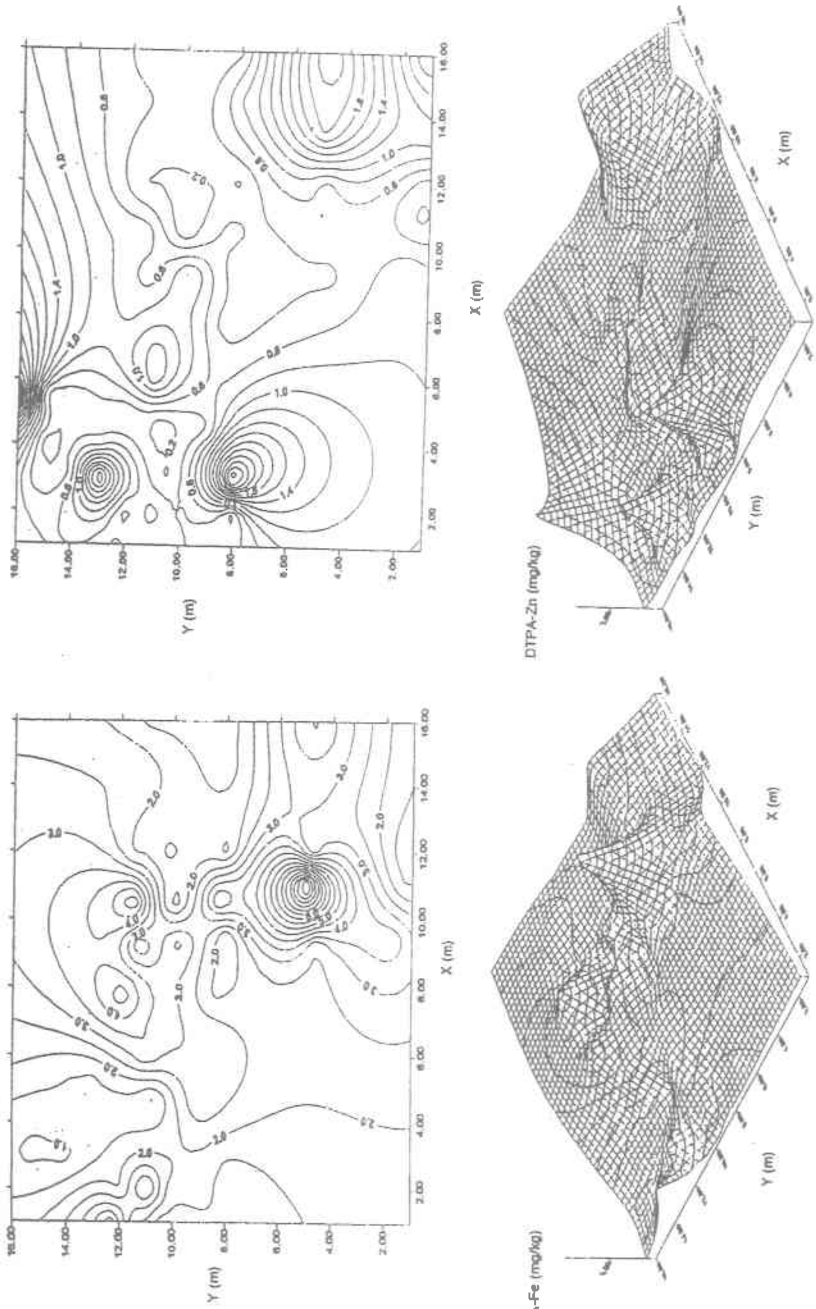

Fig. 5. Kriging map and 3 D of DTPA-Fe and Zn for the surface layer.

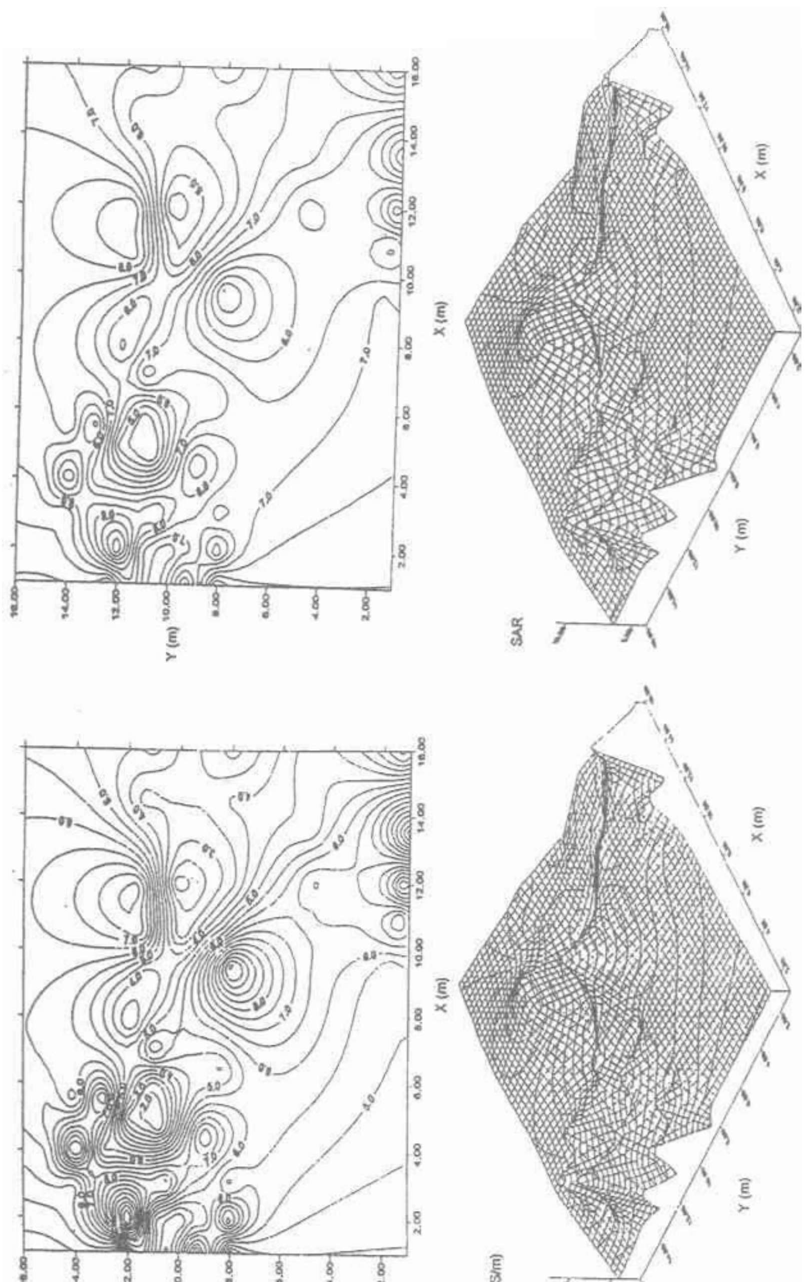

Fig. 6. Kriging and 3 D of the surface

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الإختلافات الفراغية والزمنية للتربة تحت الاستخدام الآمن لمياه رى منخفضة الجودة بمنطقة برج العرب - مصر

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تم إجراء دراسة مقارنة لتقييم الاستخدام الآمن لعدة مصادر مختلفة لمياه رى منخفضة الجودة بمزرعة محطة الصرف الصحى بمدينة برج العرب الجديدة - الساحل الشمالى الغربى - مصر خلال شهر مارس ١٩٩٩.وتمثلت هذه المصادر فى مياه صرف صحى معالج تم استخدامها في الرى لفترات زمنية ٦ ، ٣ ، ٢ سنوات ، مياه صرف صناعى معالج تم استخدامها لمدة عام واحد، مياه رى مخلوطة (مياه نيلية + مياه صرف زراعى من ترعة بهيج)، مياه أمطار كمصدر للمقارنة .

وكانت أهم النتائج المتحصل عليها كما يلى :

أولا : الخواص الطبيعية للتربة :

زيادة ثبات الحبيبات المركبة مائيا وكذلك معامل البناء مع زيادة فترات استخدام تلك المياه فى الرى ، مع اختلاف اثر نوعية مياه الرى كما يلى :

مياه صرف صحى (٦ سنوات) >مياه صرف صحى (٣ سنوات)> مياه صرف صحى (٢ سنة) > مياه صرف صناعى > مياه أمطار > المياه المخلوطة.

ولوحظ بنفس الاتجاه انخفاض قيم الكثافة الظاهرية للتربة وزيادة قيم معامل التوصيل الهيروليكى وكذلك المحتوى الرطوبى للتربة. كما لوحظ أيضا زيادة قيم معامل الاختراق فى الأراضى المعاملة كما يلى : مياه صرف صناعى > مياه صرف صحى (٦ سنوات) > مياه صرف صحى (٣ سنوات) > مياه صرف صحى(٢سنة) > مياه الأمطار > المياه المخلوطة

ثانيا : الخواص الكيمائية للتربة :

- انخفاض قيم رقم الحموضة والقلوية فى الأراضى المعاملة بتلك المياه كما يلى : مياه صرف صحى (٦ سنوات) > مياه صرف صناعى > مياه صرف صحى (٣ سنوات) > مياه صرف صحى (٢ سنة) > مياه الأمطار > المياه المخلوطة.

- ارتفاع قيم التوصيل الكهربائى كما يلى: المياه المخلوطة > مياه الصرف الصناعى > مياه الصرف الصحى (٦ سنوات) > مياه الصرف الصحى (٣ سنوات) > مياه الصرف الصحى (٢ سنة) > مياه الأمطار.
- زيادة صلاحية عناصر الرصاص والزنك والحديد كما يلى : مياه صرف صناعى > مياه الصرف الصحى (٦ سنوات) > مياه الصرف الصحى (٣ سنوات) > مياه صرف صحى (٢ سنة) > المياه المخلوطة > مياه الأمطار .
- زيادة صلاحية عناصر النيكل والمنجنيز والنحاس كما يلى: مياه صرف صحى (٦ سنوات) > مياه صرف صحى (٣ سنوات) > مياه صرف صحى (٢ سنة) > مياه صرف صناعى > المياه المخلوطة > مياه الأمطار.

ثالثا : التحليل الفراغى جيو أحصائى :

أوضح التحليل الآتى :

- موديل Semi-variogram لصلاحية عنصر الحديد والكلوريد الذائب كان Expontional model , بينما كان Spherical model لصلاحية عناصر الزنك والمنجنيز والنيكل والصوديوم الذائب، وبالنسبة لصلاحية عناصر النحاس والرصاص والتوصيل الكهربائى ونسبة الصوديوم المدمص كان Gaussian model .ثم رسمت خرئط Kriging لهذه الخصائص والتى كانت تمثل أعلى اختلافات فراغية. ولقد أوضح التحليل الجيو احصائى التغيرات الفراغية والزمنية على مستوى الاختلافات الدقيقة Micro-variability ويرجع ذلك لتعدد مصادر مياه الرى المختلفة النوعية .

أوضحت الدراسة أن استخدام مياه الصرف الصحى المعالجة لفترات طويلة ومياه الصرف الصناعى المعالجة قد أدى الي تحسين الخواص الطبيعية للتربة بينما أدى الى تدهور أو تغير نسبى فى بعض الخواص الكيميائية، بينما استخدام المياه المخلوطة قد ساعد على تدهور الخواص الكيميائية والطبيعية للتربة.