ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2521-0912 (Print)
ISSN: 2521-0513 (Online)
CODEN: JCOLBF

Journal CleanWAS (JCleanWAS)

DOI: http://doi.org/10.26480/jcleanwas.02.2023.61.68

CrossMark

RESEARCH ARTICLE

STATUS OF SOIL QUALITY ON RECLAIMED LAND IN AN ARID REGION

Ahmed Asmoay[a]*, Ibrahim Mousa[b], Ahmed Mohamed[c]

[a] Department of the Geological Science at National Research Centre, Dokki, Giza, Egypt
[b] Drilling Manager in Savola Food Group Alexandria United Company for Land Reclamation (AUCR) at Nasr City, Cairo, Egypt
[c] Department of the Geology at Faculty of Science, Assuit Univ., Assiut, Egypt
**Corresponding Author E-mail: asmoay@gmail.com*

ARTICLE DETAILS

Article History:

Received 09 June 2023
Revised 18 July 2023
Accepted 22 August 2023
Available online 24 August 2023

ABSTRACT

The study was conducted in Egypt's El Minya Governorate, where 16 soil samples were taken from reclaimed land and analyzed in the USA using a variety of indices. The study revealed that the soil was moderately alkaline, calcareous, and had salinities ranging from not salty to relatively salty. Most of the soil samples had a clay texture, with varying mineral compositions. The study also found that phosphate fertilizers had been used to improve soil fertility, but it was cautioned against using them due to the low soil fertility and potential for heavy metal contamination. The study also compared the quality index of soil, the ratio of sodium absorption, and the percent of base saturation to determine soil quality and fertility. Finally, the study found that agriculture was more extensive in 2018 and 2020 than in 2022, which could indicate a lack of farming in the current season.

KEYWORDS

Soil salinity, Saturated soil paste, Pollution, Soil condition, Land cover and land usage.

1. Introduction

Agriculture is expanding in arid regions to meet increasing food demand (Lim et al., 2020). Salinity monitoring is essential for effective land management, as salt accumulation can harm plant growth (Sumner, 1993; Oster et al., 1999). Electrical conductivity (EC) is the most common method for estimating soil salinity since it depicts a well-known natural phase of soil extracts, which can be indicative of a plant's reaction (Salinity Laboratory, 1954; Bower and Wilcox, 1965; Khorsandi and Yazdi, 2011; Zhang et al., 2021). Understanding the makeup of soil extracts is essential for understanding how salt concentrations affect soil chemistry, nutrient absorption, heavy metal contamination, and pedogenetic cycles (Richards 1954; Hossain et al., 2020; Bockmann et al., 202). The most popular method for obtaining soil-based extracts is saturated soil paste (Aboukila and Norton, 2017).

Several experts have analyzed the soil condition (Aboukila and Norton, 2017; Asmoay, 2017; Asmoay et al., 2019; Hossain et al., 2020; Bockmann et al., 2021; Alves et al., 2022; Moldovan et al., 2022; Seo et al., 2022; Yan et al., 2022; Zhang et al., 2022; Wang et al., 2023). The main goal of the study is to assess soil quality and conditions over the previous 12 years, covering salinity, pollution from heavy metals, and agricultural extension.

1.1 Location

The researched area occupies a spot in the El Minya Governorate's southwest region between latitudes of 27° 42` and 27° 50` N and longitudes of 30° 14` and 30º 35` E (Figure 1). Geomorphology indicates that it is a newly excavated alluvial plain on the eastern edge of the Western Eocene plateau (Figure 1; Said, 1981). From bottom to top, the rock unit of the stratigraphic column is made up of conglomerate, sand dunes, Nile silt, and wadi deposits in the Quaternary, as well as gravel and the Minia Formation, Samalut Formation, Moghra Formation, Gebel Qatrani, and Samalut Formation (Figure 2; Said, 1990).

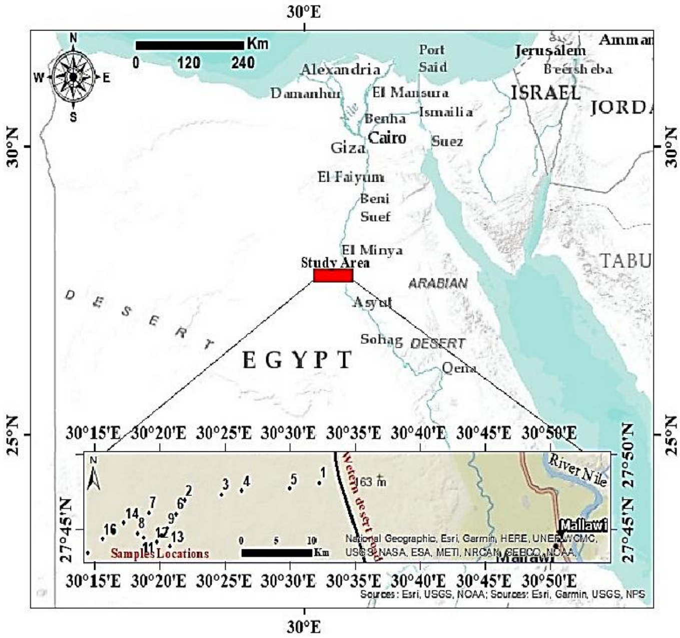


Figure 1: Location map of the study area.

2. Materials and Methods

16 soil samples were collected from the reclaimed area located west of the western desert road, west of Mallawi city, in the El Minya Governorate of Egypt. The samples were run through a 2-mm mesh and allowed to air dry

Quick Response Code | **Access this article online**

Website: www.jcleanwas.com

DOI: 10.26480/jcleanwas.02.2023.61.68

Cite the Article: Ahmed Asmoay, Ibrahim Mousa, Ahmed Mohamed (2023). Status of Soil Quality on Reclaimed Land in An Arid Region. *Journal CleanWas, 7(2): 61-68.*

prior to being examined physically and chemically. Soil-saturated paste extracts were studied using technique WCC-103 at Stukenholtz Laboratory, Inc., located at 2924 Addison Ave. E., P.O. Box 353, Twin Falls, USA, following the procedure outlined in (Gavlak et al., 2005). According to CCME (2001), a soil quality indicator (SQI) can be utilized to assess soil quality for farm use. The SQI values were divided into one of five categories, ranging from low quality (0–45) to excellent quality (95–100), with marginal, fair, and good quality falling in between these values (Marvin et al., 2004).

To evaluate the risk of sodium in soil, The ion contents referred to as epm, as described by Richards, are utilized in what follows equation (Eq. 1) (Richards, 1954):

$$SAR = Na/\sqrt{Ca + Mg/2} \tag{1}$$

Sodium absorption ratio (SAR) values are divided into four categories by Joshua & Musgrave (2017): no risk (>3), moderate risk (3-6), high risk (18–26), and severe risk (>26).

Cation exchange capacity (CEC) values, as noted can be used to identify the texture of soil, with values ranging from 5 denoting sand, 5–10 indicating fine sandy loam, 10-15 indicating loam, 15–30 indicating clay loam, and >30 indicating clay (Sonon et al., 2022). Additionally, CEC values can be used to detect the clay minerals present in the soil, with kaolinite ranging from 3–15, illite ranging from 15–40, and montmorillonite ranging from 40–120.

According to the base saturation percentage (BS%) is a measure of soil fertility and may be computed using the following equation (Eq. 2), where the concentrations are expressed in meq/100g (Sonon et al., 2022).

$$BS\% = [(Ca + Mg + K)/CEC] \times 100 \tag{2}$$

According to the pollution index can be determined via the following equation (Eq. 3) (Hakanson, 1980; Gao et al., 2013; Ming, 2014).

$$Pi = Ci/Si \tag{3}$$

According to Hooda, *Si* is the reference content of this metal in the soil extracts, and *Ci* is the metal concentration in the soil extracts expressed in ppm (Hooda, 2010). According to some study, the total pollution indices (Psum) are calculated using the following formula (Eq. 4) (Hakanson, 1980; Gao et al., 2013; Ming, 2014).

$$P_{sum} = \sqrt{((Ave\ Pi)2 + (Max\ Pi)2)/2} \tag{4}$$

Max Pi is the maximum level of the Contamination indices, while Ave Pi is the mean Pi number for all metals. According to Psum values have been separated into five grades: clean (1), slight pollution (1-2), milder pollution (2–3), considerable pollution (3-5), and severe pollution (>5) (Gao et al., 2013; Ming, 2014).

Using a potential ecological risk assessment approach, the effects of various pollution levels were assessed. The total index of potential ecological risk (RI) captures the entire consequences of many contaminants (Hakanson, 1980). The subsequent equation was used to calculate RI (Eq. 5; Hakanson 1980; Zhang et al., 2022):

$$RI = \sum_{i=1}^{n} E_r^i \tag{5}$$

This equation (Eq. 6) calculates E_r^i, which denotes the impact of a single pollutant on the environment in soils (Hakanson, 1980; Zhang et al., 2022).

$$E_r^i = T_r^i x \mathrm{C}_\mathrm{r}^\mathrm{i} \tag{6}$$

A group researchers identified the metal's toxicity-reactivity value as T_r^i. $\mathrm{C}_\mathrm{r}^\mathrm{i}$ is a metal's pollution coefficient, which can be determined via this equation (Eq. 7) (Yan et al., 2022):

$$C_r^i = c^i \,/\, c_f^i \tag{7}$$

According to Hooda, c^i is the observed quantity of metal in soil extracts and c_f^i is the standard value for this metal within the extracts (Hooda, 2010). According to a group researcher, RI levels were categorized into four rates: minimal ecological risk (50), moderate ecological risk (50–100), significant ecological risk (100–200), and severe ecological risk (>200) (Ma et al., 2011).

3. Result and Discussion

Egypt's intake of food is rising in tandem with the country's rising population density. However, the expansion of construction is reducing the productivity of the soils in the Nile Valley. Since the government is pushing businesses to recover land for expanding agriculture, there is a pressing need to improve the condition of the soil in these places. These areas are seen by the research area as prospective agricultural development.

3.1 Physicochemical Variables

The extracts pH examined in the study ranged from weakly alkaline (7.9) to moderately alkaline (8.2), with implications for plant nutrient availability, microbial activity, and the heavy metal adsorbed and immobilized. This is in line with previous research by (Denny, 2002; Kabata-Pendias, 2011). The EC values of the soil extracts, as per Richards, varied from 1720 to 8700 µS/cm, indicating that the soil salinity fluctuated between non-saline and moderately saline (Richards, 1954). For most of the samples analyzed, these values exceeded the standard limits defined by FAO (Table 1) (FAO, 1994). In the samples under investigation, $CaCO_3$% spanned between 5.3 and 14.5% (Table 1), with its content rising over 5% to signify the calcareous nature of the soils (Lindsay, 1979).

CEC readings in the investigated soils varied between 20 to 73.5 meq/100g, indicating the particles' capacity to hold cations, as noted (Table 1) (Aran et al., 2008). CEC levels may also be utilized to identify the soil texture type, with about 25% of samples exhibiting clay loam and 75% exhibiting clay, according to (Sonon et al., 2022). According to a study, CEC measurements may be utilized as well to determine the different types of clay minerals present in soil, with illite being present in 25% of samples and montmorillonite being present in 75% (Asmoay, 2017; Sonon et al., 2022). According to a study, higher levels of organic matter (OM%) indicate an improved ability to maintain heavy metals that lead to soil pollution (Brady and Weil, 2007). The OM% in the soil extracts ranged from 0.31 to 1.15% (Table 1).

With concentrations of 999, 864, 833, 340, 91, 25, and 18 correspondingly, the average main ion concentrations in the soil extracts could be sorted as follows: SO4 > Cl > Ca > K > Na > Mg > NO3 (Table 1). According to these findings imply that evaporite and carbonate minerals are the sources of these ions (Mohamed et al., 2022). While Na and NO3 values were over FAO criteria in 19% and 37% of samples, respectively, Ca contents were generally above the FAO guideline limit (Table 1). The FAO-recommended standards for K and SO4 were surpassed in every sample (Table 1). According to Asmoay, all samples had N and NH3 values that were higher than the FAO guidelines as an outcome of human behaviors, which also influence N-compounds and the decomposition of organic matter (Asmoay, 2017). highlighting the function of fertilizers as human-induced sources and the weathering of rocks as natural sources, most samples revealed P content that was above FAO standards (Bueis et al., 2019; Table 1).

3.2 Heavy Metals (HM)

If the amounts of heavy metals (HM) in soil surpass reference limits, soil pollution can occur, which can lead to harmful effects on human health if it gets into food and water, as noted by (Asmoay et al., 2019). In the examined soil samples, Fe levels varied from 2.8 to 6.3 ppm, which weren't over the FAO criteria and Hooda reference levels (Table 1) (Hooda, 2010). According to the amount of Mn fluctuated between 3.1 and 4.6 ppm, surpassing the FAO limit, and can originate from phosphate fertilizers and minerals like augite and hornblende in soils (Omer, 2003; Asmoay, 2017). According to ATSDR, Cu exists in both human and animal excrement and is a necessary component of plant and animal metabolic processes (ATSDR, 2002). The amounts of Cu in the soil extracts oscillated between 0 and 0.2 ppm (Table 1). Zn, which can be abundant in igneous rocks and phosphate fertilizers, is essential for all biotas. According to some study, it was present in the samples that were analyzed in amounts ranging from 0.3 to 0.9 ppm (Table 1) (Friberg et al., 1986; Asmoay, 2017). Above the FAO and Hooda guidelines, the B level in the analyzed soil samples oscillated between 1.1 and 17 ppm and can be emitted through sediments and sewage (FAO and Hooda, 2010). According to the WHO, elevated levels can harm the body (WHO, 2022).

Table 1: Physicochemical variables in the studied soil's extracts.

Variables	Min.	Max.	Average	Median	Q1	Q3	FAO, 1994	Hooda, 2010	Samples exceeded the reference limits	
									FAO, 1994	Hooda, 2010
pH	7.9	8.2	8.03	8	8	8.1	6-8.5			
EC (µS/cm)	1720	8700	5934	6200	4785	7900	3000		All samples except 1, 4 & 16	
$CaCO_3$ %	5.3	14.5	10.7	11.05	8.2	13.2				
OM %	0.31	1.15	0.56	0.51	0.45	0.58				
CEC (meq/100g)	20	73.5	48.7	51.9	24.5	68.7				
Ca (ppm)	318	1370	833	792	419	1236	401		All samples except 1, 4, 6 & 8	
Mg (ppm)	16	34	25	27	21	29	61			
Na (ppm)	16	418	91	32	23	90	920			
K (ppm)	172	655	340	355	265	405	78		All samples	
Cl (ppm)	98	4338	864	229	128	634	1063		5, 11 &16	
SO_4 (ppm)	999	999	999	999	999	999	960		All samples	
NO_3 (ppm)	4	88	18	7.5	5.5	19	10		1, 4, 5, 10, 11 &16	
N (ppm)	25	50	30	30	25	30	5		All samples	
NH_3 (ppm)	3.3	13	6.7	5.8	5.4	7.3	5		All samples	
P (ppm)	7	14	9.7	9.5	8.8	11	2		All samples except 1, 4 & 6	
Fe (ppm)	2.8	6.3	4.2	4.3	3.3	4.8	5	5	1, 4 & 7	1, 4 & 7
MN (ppm)	3.1	4.6	3.6	3.5	3.2	3.9	0.2	5	All samples	
Cu (ppm)	0.0	0.2	0.11	0.10	0.10	0.10	0.2	2.5		
Zn (ppm)	0.3	0.9	0.45	0.40	0.35	0.50	2	2		
B (ppm)	1.1	17	5.8	4.8	2.6	7.7	2	2	All samples except 1, 4 & 6	All samples except 1, 4 & 6
SAR	0.17	4.1	0.89							
SQI%	36	64	43							
BS%	8.38	12.83	11.05							
P_{sum}	0.43	4.43	1.51							
RI	2.02	9.66	4.12							

Cite the Article: Ahmed Asmoay, Ibrahim Mousa, Ahmed Mohamed (2023). Status of Soil Quality on Reclaimed Land in An Arid Region. *Journal CleanWas, 7(2): 61-68.*

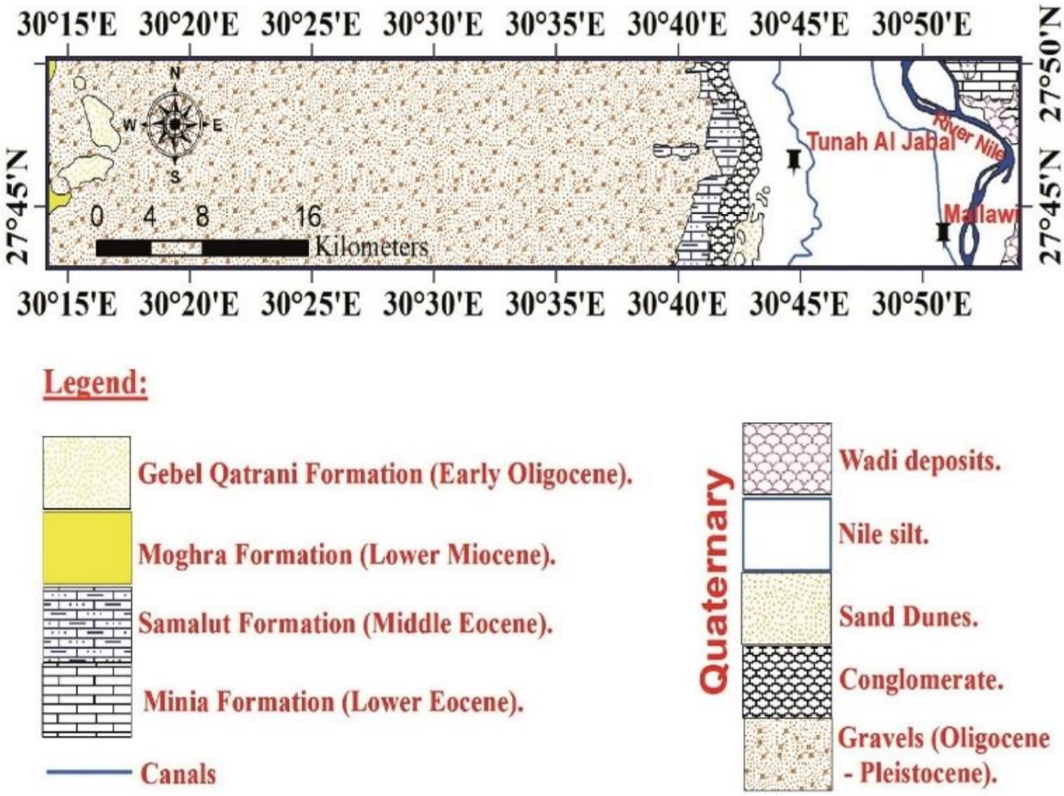


Figure 2: Geologic map of the study area After [49].

3.3 Soil Quality

According to SQI values (Table 1 and Figure 3), the soil's suitability for cultivation changed from poor in 75% of the samples to marginal in 25% because of a rise in the level of soluble elements over the FAO restrictions. SAR values spanning 0.17 to 4.1 (Table 1 and Figure 4), indicating that there was no threat in 88% of the studied soil extracts, according to (Joshua and Musgrav, 2017). The BS% values in the tested soils fell between 8.38 and 12.83%, suggesting that they were less fertile and could benefit from lime or fertilizer amendments. As stated by Table 1, and Figure 5, these toxic metal sources have the potential to affect soils and groundwater (ALCL, 2013; Sonon et al., 2022).

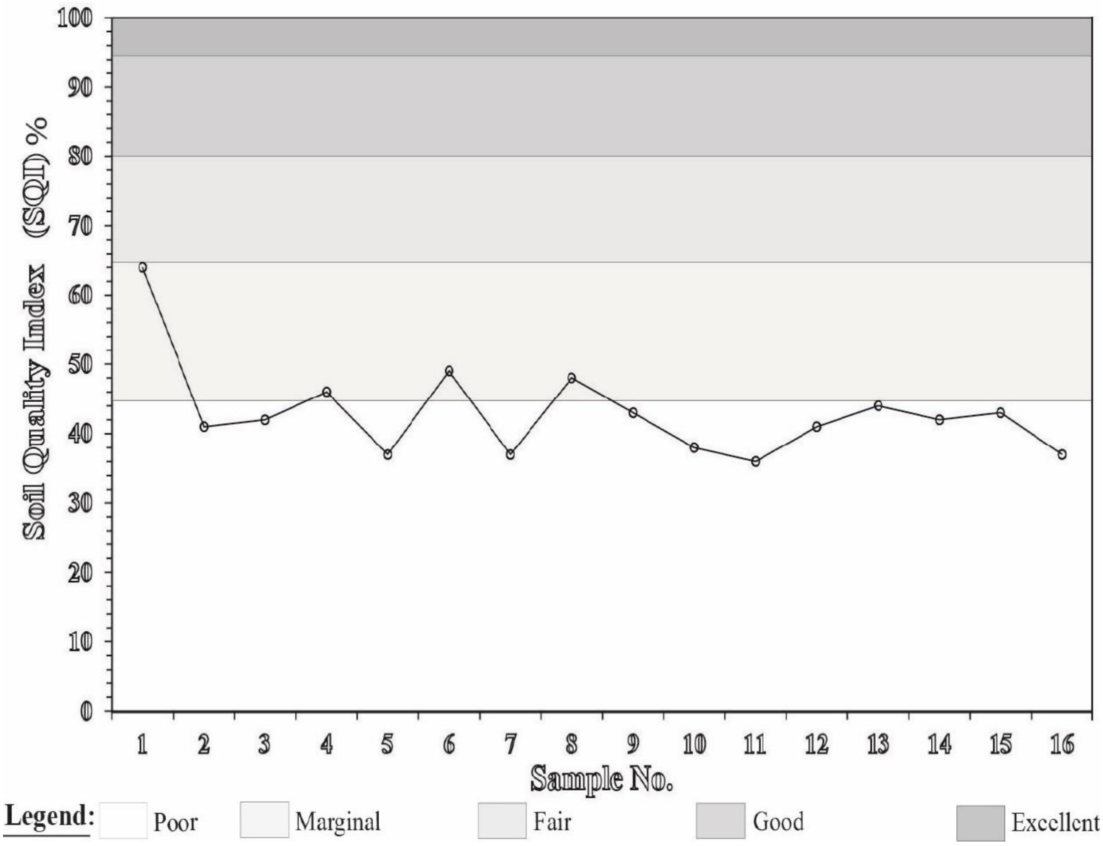


Figure 3: SQI values classification for the examined samples

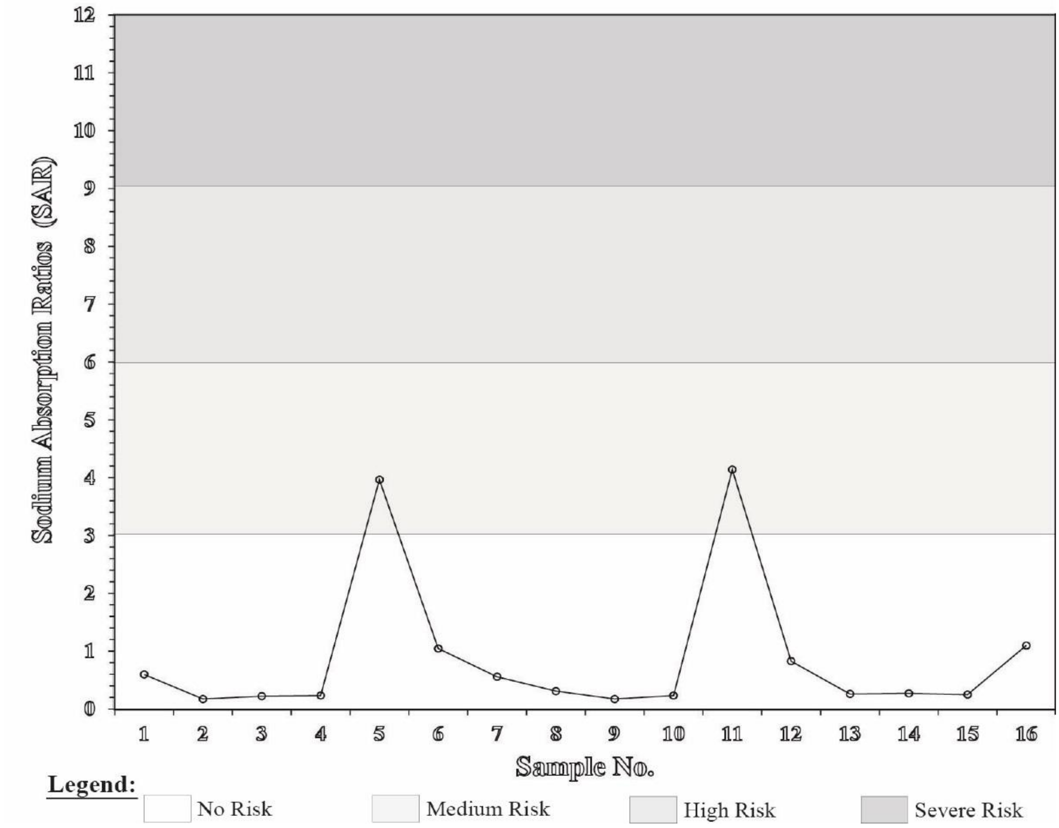


Figure 4: SAR values classification for the studied samples.

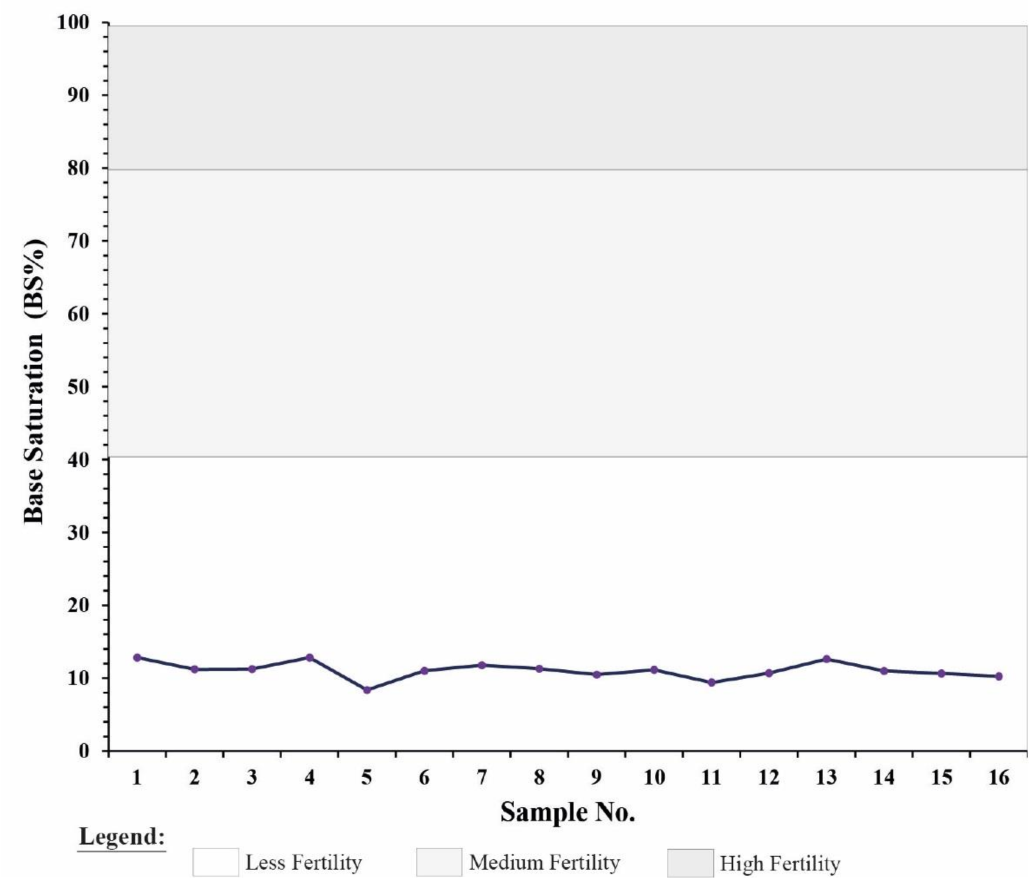


Figure 5: BS values classification for the investigated samples.

3.4 HM Content Evaluation in Soil Extracts

HM accumulating in soil and water may threaten plant, human, and animal health, as mentioned and this can be shown by simulating HM concentrations by indices (Asmoay, 2017; Asmoay et al., 2019; Zhang et al., 2022). The P_{sum} numbers in the analyzed samples fell between 0.43 and 4.43 (Table 1 and Figure 6). According to the levels of HM in the soil extracts suggested no negative effects on health (Hakanson, 1980; Hooda, 2010; Gao et al., 2013; Ming, 2014; Moldovan et al., 2022). According to the RI values fluctuated from 2.02 to 9.66, exhibiting insignificant ecological danger related to the quantities of HM in soil extracts (Hakanson, 1980; Hooda, 2010; Yan et al., 2022). As an outcome, the acute impact of the HM contents in the soil extracts was negligible.

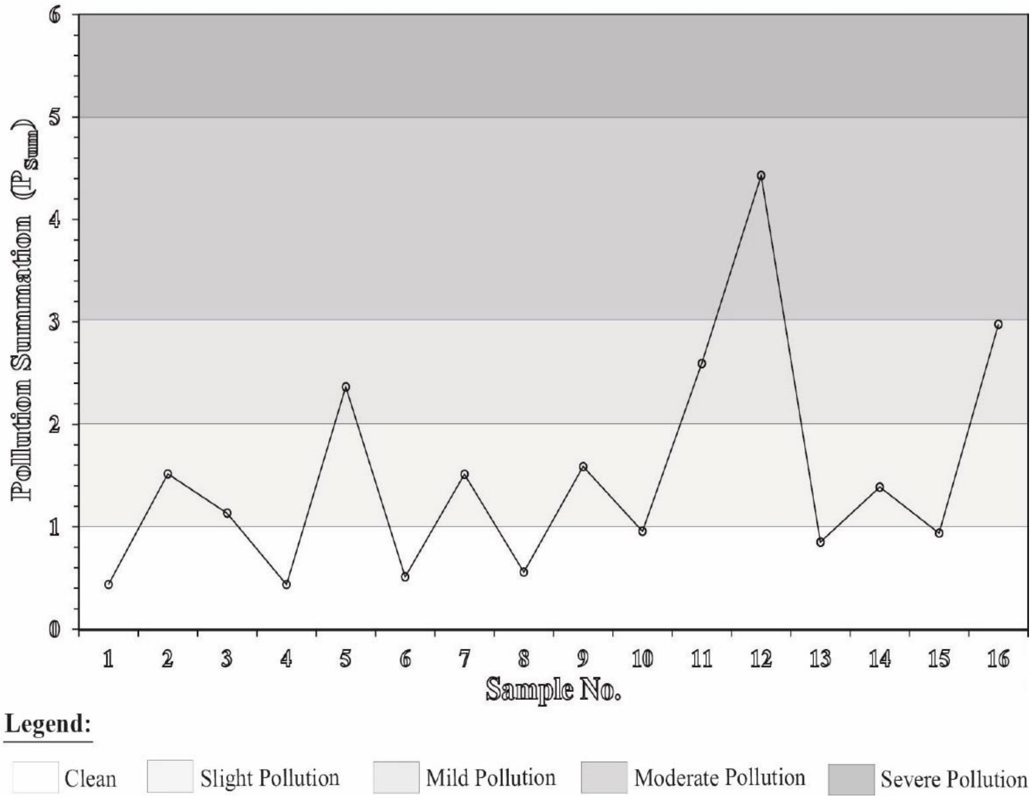


Figure 6: Psum values classification for the studied samples.

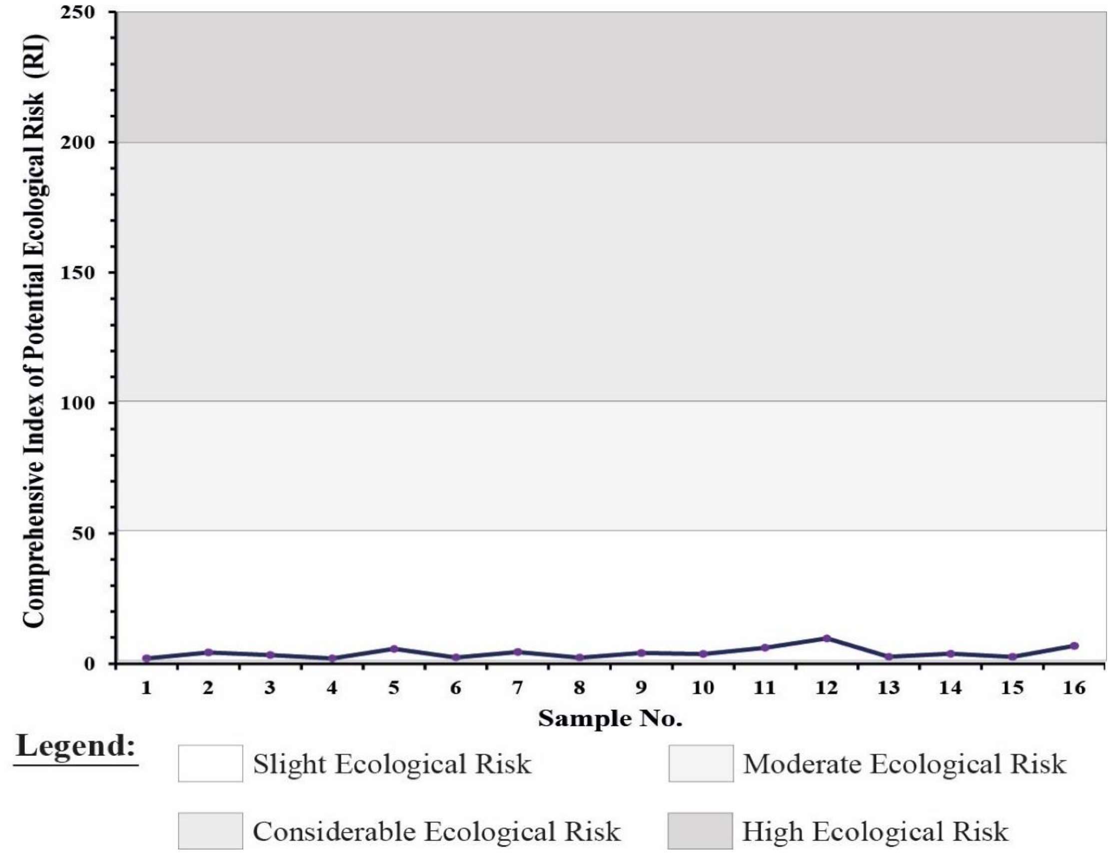
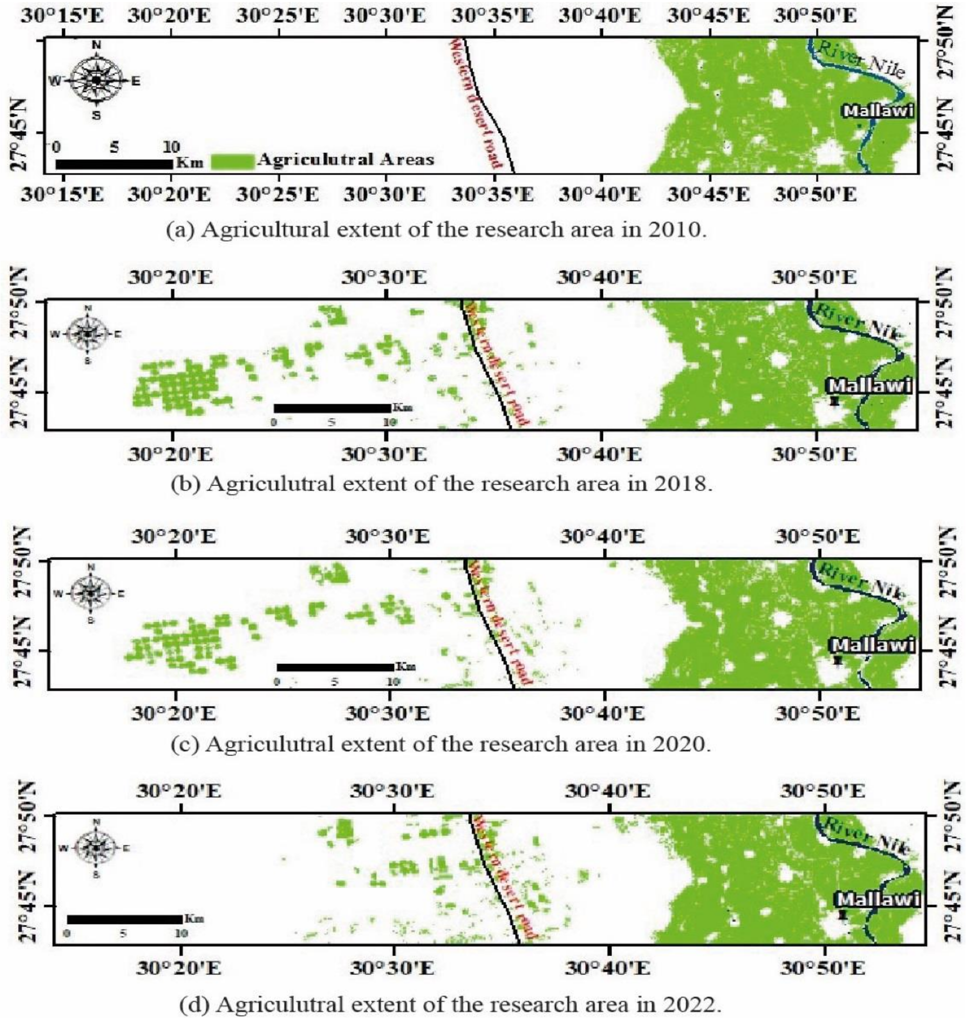


Figure 7: RI values classification for the examined samples.

3.5 Land use-land cover (LU-LC) changes

According to a study, using Satellite images, variations in the terrain through time can have a qualitative as well as numerical influence on the environment (Verma et al., 2020). According to some study, over-irrigation processes in the UAE contributed to reducing groundwater levels, which had an impact on agricultural productivity (Elmahdy and Mohamed, 2012; Ghebreyesus et al., 2016; Khan et al., 2019). The areas of land devoted to agriculture in Egypt are decreasing because of the country's dense population in the productive Nile Valley sector. Landsat imagery inspected using ArcMap software has revealed that this has resulted in a food crisis, prompting initiatives to reclaim the desert and construct fresh groundwater wells to irrigate new areas. These maps illustrate how factors have caused changes in land usage. Agricultural fields in the study area improved in 2018 and 2020 before lowering in 2022 (Figure 8). Agricultural harvests or a lack of farming activities during this season may be to blame for this reduction.



(a) Agricultural extent of the research area in 2010.

(b) Agriculutral extent of the research area in 2018.

(c) Agriculutral extent of the research area in 2020.

(d) Agriculutral extent of the research area in 2022.

Figure 8: LU-LC changes in agricultural extent of the study area.

4. Conclusion

The pH was between mildly and moderately alkaline in the soil extracts, which had an impact on the availability, adsorption, and stability of heavy metals. The soils oscillated from not salty to moderately saline with over 5% $CaCO_3$, indicating calcareous soil with most of the clay texture and montmorillonite as the dominant clay mineral. Nitrogen and phosphorus compounds exceeded FAO limits, indicating human activity. With the notable exceptions of Fe, Mn, and B, the amounts of heavy metals in soil extracts were within recommended guidelines. According to SQI values, the state of the soil was poor to marginal, necessitating the use of lime and fertilizers to prevent contamination by heavy metals. Landsat data suggested that agriculture grew between 2018 and 2020 until lowering in 2022 because of unique circumstances like no cultivation or harvest.

References

Aboukila, E.F., Norton, J.B., 2017. Estimation of saturated soil paste salinity from soil-water extracts. Soil Sci., 182, Pp. 107–113.

ALCL, 2013. Understanding cation exchange capacity and % base saturation. A & L Canada Laboratories, INC., Fact Sheet, Pp. 552.

Alves, A.C., Souza, E.R., Melo, H.F., Pinto, J.G.O., Junior, F.E., Júnior, V.S., Marques, F.A., Santos, M.A., Schaffer, B., Gheyi, H.R., 2022. Comparison of extracts extraction methods for estimating electrical conductivity in soils with contrasting mineralogical assemblages and textures. Catena, Catena, 218, Pp. 106581. https://doi.org/10.1016/j.catena.2022.106581.

Aran, D., Maul, A., Masfaraud, J., 2008. Surface geosciences (pedology): A spectrophotometric measurement of soil cation exchange capacity based on cobaltihexamine chloride absorbance. Geoscience, 340, Pp. 865-871.

Asmoay, A.S., Salman, S.A., El-Gohary, A.M., Sabet, H.S., 2019. Evaluation of heavy metal mobility in contaminated soils between Abu Qurqas and Dyer Mawas Area, El Minya Governorate, Upper Egypt. Bulletin of the National Research Centre, 43, Pp. 88. https://doi.org/10.1186/s42269-019-0133-7.

Asmoay, A.S.A., 2017. Hydrogeochemical Studies on the Water Resources and Soil Characteristics in the Western Bank of the River Nile between Abu Qurqas and Dayr Mawas, El Minya Governorate, Egypt. Ph.D. Thesis, Fac Sci, Al-Azhar Univ, Egypt.

ATSDR, 2000. Toxicological profile for manganese. Atlanta, GA, United States Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry.

Bockmann, S., Titov, I., Gerken, M., 2021. Extraction of Soil Extracts into a Microfluidic Chip. Agri. Engineering, (3), Pp. 783–796.https://doi.org/10.3390/agriengineering3040049.

Bower, C.A., Wilcox, L.V., 1965. Soluble salts. In: Black, C.A. (Ed.), Methods of Soils Analysis. 2. American Society of Agronomy, Madison, Wisconsin, U.S.A., Pp. 933–940.

Brady, N.C., Weil, R., 2007. Nature and properties of soils (14th edn). Prentice Hall, Upper Saddle River, NJ.

Bueis, T., Bravo, F., Pando, V., Kissi, Y., Turrión, M., 2019. Phosphorus availability in relation to soil properties and forest productivity in Pinus sylvestris L. plantations. Annals of Forest Science, 76 (97), Pp. 1-13. https://doi.org/10.1007/s13595-019-0882-3.

CCME, 2001. Sediment Quality, Canadian Council of Ministers of the Environment, Index 1.0, User's Manual, Winnipeg.

Conoco, 1987. Geologic map of Egyp. Egyptian general authority for petroleum. In: Scale (1:500,000). Between El-Minia and Sohag.

Denny, H., 2002. Plant mineral nutrition. In: Ridge, I. (Ed.), Plants. Oxford Univ. Press, New York, Pp. 167-220.

Elmahdy, S.I., Mohamed, M.M., 2012. Topographic attributes control groundwater flow and groundwater salinity of Al Ain, UAE: A prediction method using remote sensing and GIS. J Environ Earth Sci., 2, Pp. 1–13.

FAO, 1994. Water Quality for Agriculture. Food and Agriculture Organization. http://www.fao.org/3/t0234e/T0234E00.htm#TOC

Friberg, L., Nordberg, G.F., Vouk, V.B., 1986. Handbook on the toxicology of metals, 2nd ed. Amsterdam, Elsevier Science Publishers, Pp. 664-679.

Gao, J.X., Dang, H.B., Zheng, M., Liu, L., Jiang, L.Y., 2013. Heavy metal pollution assessment of farmland soil in suburb in Zhengzhou City. China. Agric Sci. Bull., 29, Pp. 116–120.

Gavlak, R.G., Horneck, D.A., Miller, R.O., 2005. Method WCC-103 from: Soil, Plant, and water reference method for the Western region 3rd Ed.

Ghebreyesus, D.T., Temimi, M., Fares, A., Bayabil, H.K., 2016. A multi-satellite approach for water storage monitoring in an arid watershed. Geosciences 6. https://doi:10.3390/geosciences6030033.

Hakanson, L., 1980. An ecological risk index for aquatic pollution control. A sedimentological approach. Water Res., 14, Pp. 975–100.

Hooda, P.S., 2010. Trace element in soils Wiley-Blackwell; 1st edition. ISBN: 978-1-405-16037-7.

Hossain, M.S., Rahman, G.M., Solaiman, A.R.M., Alam, M.S., Rahman, M.M., Mia, M.B., 2020. Estimating electrical conductivity for soil salinity monitoring using various soil-water ratios depending on soil texture. Commun. Soil Sci. Plant Anal., 51 (5), Pp. 635–644.

Joshua, E., Musgrave, A., 2017. Interpreting water quality test results. NSW DPI Agriculture Water Unit, Primefact 1344 first edition.

Kabata-Pendias, A., 2011. Trace elements in soils and plants. Fourth edition. CRC Press, Boca Raton FL., Pp. 534.

Khan, Q., Kalbus, E., Alshamsi, D.M., Mohamed, M.M., Liaqat, M.U., 2019. Hydrochemical analysis of groundwater in Remah and Al Khatim regions. United Arab Emirates. Hydrology, 6 (3), Pp. 60. https://doi.org/10.3390/hydrology6030060.

Khorsandi, F., Yazdi, F.A., 2011. Estimation of saturated paste extracts' electrical conductivity from 1:5 soil/water suspension and gypsum. Commun. Soil Sci Plant Anal., 42, Pp. 315–321.

Lim, S.S., Yang, H.I., Park, H.J., Park, S.I., Seo, B.S., Lee, K.S., Lee, S.H., Lee, S.M., Kim, H.Y., Ryu, J.H., Kwak, J.H., Choi, W.J., 2020. Land-use management for sustainable rice production and carbon sequestration in reclaimed coastal tideland soils of South Korea: A review. Soil Sci Plant Nutr., 66, Pp. 60–75.

Lindsay, W.L., 1979. Chemical Equilibria in Soil. John Wiley & Sons, New York.

Ma, J.H., Wang, X.Y., Hou, Q., Duan, H.J., 2011. Pollution and potential ecological risk of heavy metals in surface dust on urban kindergartens. Geogr Res., 30, Pp. 486–495.

Marvin, C., Grapentine, L., Painter, S., 2004. Application of a sediment quality index to the lower laurentian great lakes. Environ Monit Assess., 92, Pp. 1–16.

Ming, H.U., 2014. Distribution characteristics and pollution assessment for the farmland soil heavy metals in Dali County. J. Arid. Land Resour. Environ., 28, Pp. 79–84.

Mohamed, A., Asmoay, A., Alshehri, F., Abdelrady, A., Othman, A., 2022. Hydro-Geochemical Applications and Multivariate Analysis to Assess theWater–Rock Interaction in Arid Environments. Appl Sci J., 12 (6343), Pp. 1-13. https://doi.org/10.3390/app12136340.

Moldovan, A., Torok, A.I., Kovacs, E., Cadar, O., Mirea, I.C., Micle, V., 2022. Metal contents and pollution indices assessment of surface water, soil, and sediment from the aries, River Basin Mining Area, Romania. Sustainability, 14, Pp. 8024. https://doi.org/10.3390/su14138024.

Omer, A.A.M., 2003. Impact of the Pleistocene Nile basin sediments on the distribution of iron and manganese in the groundwater, Tema-Nag Hammadi area, Nile Valley, Egypt. The 3rd Intern. Conf Geol Africa, 1, Pp. 21-23.

Oster, J.D., Shainberg, I., Abrol, I.P., 1999. Reclamation of salt affected soils. In: Skaggs, R.W., van Schilfgaarde, J. (Eds.), Agricultural Drainage. ASA-CSSA-SSSA, Madison, WI, Pp. 659–691.

Richards, L., 1954. Diagnosis and improvement of saline and alkali soils. In Richards L (ed.) US Department of Agriculture Handbook No. 60. US Government Printing Office, Washington, Pp. 98–105.

Said, R., 1981. The geological evolution of the River Nile. Springer Verlag, New York, Berlin, Pp. 151.

Said, R., 1990. The geology of Egypt. Balkema, Rotterdam, Brookfield, Pp. 734.

Salinity Laboratory US, 1954. Diagnoses and improvement of saline and alkali soils. Agriculture Handbook No. 60. USDA.

Salman, S., Abou El-Anwar, E., Asmoay, A., Elnazer, A., 2021. Geochemical, mineralogical and pollution assessment of River Nile sediments at Assiut Governorate, Egypt. Journal of African Earth Sciences, 180, Pp. 104227. https://doi.org/10.1016/j.jafrearsci.2021.104227.

Seo, B., Jeong, Y., Baek, N., Park, H., Yang, H., Park, S., Choi, W., 2022. Soil texture affects the conversion factor of electrical conductivity from 1:5 soil-water to saturated paste extracts. Pedosphere, 32 (6), Pp. 905–915. http://doi: 10.1016/j.pedsph.2022.06.023.

Sonon, L.S., Kissel, D.E., Saha, U., 2022. Cation exchange capacity and base saturation. UGA Cooperative Extension Circular, 1040, Pp. 1-3.

Sumner, M.E., 1993. Sodic soils: new perspectives. Aust J. Soil Res., 31, Pp. 683–750.

Verma, P., Singh, P., Srivastava, S.K., 2020. Impact of land use change dynamics on sustainability of groundwater resources using earth observation data. Environ Dev Sustain., 22, Pp. 5185–5198. https://doi.org/10.1007/s10668-019-00420-6.

Wang, Q., Li, X., Zhao, C., Pei, L., Wan, S., 2023. Evaluation analysis of the saturated paste method for determining typical coastal saline soil salinity. Soil & Tillage Research, 225, Pp. 105549. https://doi.org/10.1016/j.still.2022.105549.

WHO, 2022. Guidelines for drinking-water quality: fourth edition incorporating the first and second addenda. ISBN 978-92-4-004506-4

Yan, T., Zhao, W., Yu, X., Li, H., Gao, Z., Ding, M., Yue, J., 2022. Evaluating heavy metal pollution and potential risk of soil around a coalmining region of Tai'an City, China. Alex Eng J., 61, Pp. 2156–2165.

Zhang, J., Guan, Y., Lin, Q., Wang, Y., Wu, B., Liu, X., Wang, B., Xia, D., 2022. Spatiotemporal differences and ecological risk assessment of heavy metal pollution of roadside plant leaves in Baoji City, China. Sustainability, 14, Pp. 5809. https://doi.org/10.3390/su14105809

Zhang, J.R., Zhang, Z.T., Chen, J.Y., Chen, H.Y., Jin, J.M., Han, J., Wang, X.T., Song, Z.H., Wei, G.F., 2021. Estimating soil salinity with different fractional vegetation cover using remote sensing. Land Degrad Dev., 32, Pp. 597–612