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POLLUTION CLASS AND ECO-TOXICOLOGICAL RISK ASSESSMENT OF HEAVY METALS IN SEDIMENT ALONG EL-KHADRAWIA DRAIN

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ABSTRACT

El-Khadrawia drain has number of anthropogenic activities including fishing, irrigation and discharge of Qusena industrial zone and industrial Mubark city that pose a risk of heavy metals in the drain and reduce economic environment. Field and laboratory analyses were carried out to assess contamination level and potential environmental risk on sediment along El-Khadrawia drain. Steel grab sampler was used to collect six sediment samples in triplicate sediment layers with 0-20 cm for quality control and quality assurance of sampling technique. Procedures of sediment chemistry characterization including extraction (Suspension extraction (decantation method) & microwave digestion technique) and geochemical analysis for eco-toxicology using Sediment Quality Guideline (SQGs), Sediment Contamination Index (SCI) and Potential Ecological Risk Index (PERI) were carried out for trace elements Aluminum: (Al), Nickel (Ni), Iron (Fe), Manganese (Mn), Cobalt (Co), Cadmium (Cd), Chromium (Cr), Zinc (Zn), Cupper (Cu) and Lead (Pb) in sediment samples along El-Khadrawia drain and El-Rayah El-Menoufy (self-investment development) to assess and predict risk for the environment and public. The research showed all metal concentrations in sediment samples, except Cr in all samples were greater than the permission limits of (SQGs) and had effect low range for adverse biology for organisms. Sediment Contamination Index (SCI) and Potential ecological Risk Index (PERI) reported all sites samples were dangers and had high rank of toxicology. The other metals concentration had variables incidence of adverse biological effect (6-70%).

Key Words: Trace elements; El-Khadrawia drain; sediment quality; sediment contamination index.

1. INTRODUCTION

Sediment deposited naturally at the bottom of water resources by precipitation, ion exchange, adsorption, hydrolysis and chelation processes. Environmentally, sediment is a sensitive indicator and geochemical contaminations for toxic trace elements ranks and sources that clarified recent environmental changes of chemical pollutants in aquatic ecosystem **(Zhou et al., 2021)**. Anthropogenic human activity and industrialization lead to serious environmental contamination by trace elements along ecological system **(Sun, et al., 2020)**. It represents serious environmental hazard impacts and significant source of commonly 23 heavy metals in high concentrations and their special property of bio-accumulation to aquatic biodiversity of many species organisms in aquatic environment that transfer from sediments causing ecological imbalances **(Uzairu et al., 2009; Javed et al., 2018 and Yang, et al., 2018)**

High ranks of heavy metals discharge in water column from sediment based on sediment pH, physical and chemical characterization of the aquatic environment and absorption & sedimentation processes of metals that depend on the composition including grain size, carbonate content, level of organic matter and Fe–Mn oxy-hydroxides **(Yao & Gao, 2007 and Hazrat et al., 2019)**. Currently, growing movement for industry leads to reduce its wastewater and treat it before discharge to achieve societal and environmental pressures and provide economic and financial benefits which consider wastewater as the potential non-convention resource for recycling after suitable treatment **(UN-Water, 2015; UN-Water, 2016 and UN-Water, 2021)**. Recently, many studies focused on research along biological half-life of heavy metals in the aquatic environment that reported a major problem to reduce pollution sources and toxic action of heavy metals on different types of aquatic life **(Yaroshenko et al., 2017)**. Several studies had highlighted the significance of periodic examination of pollutants measurements in aquatic ecosystems using various analysis techniques including in-situ (sensor technology such as pH, EC, DO) and ex-situ (spectrometric and chromatographic methods) **(Peyravi et al., 2020 & Sambito and Freni, 2021)** to perform a complex environmental assessment.

Many researches highlighted the guidelines, references and transport mechanisms and chemical speciation of heavy metals for aquatic sediment quality in water body using various indices **(Usha & Ranga, 2011 and Shafaqat et al., 2020)**. Consequently, potential ecological risk index (PERI) **(Zhu et al., 2013**), sediment pollution index (SCI) **(Singh et al. 2002)** and sediment quality guidelines **(CSQG, 2001)** are vital for the assessment of metal pollution in sediments and water resource that has a great socio-economic potential. El-Khadrawia drain has number of anthropogenic activities including fishing, irrigation and discharge of Qusena industrial zone and industrial Mubark city that pose a risk of heavy metals in the drain and reduce economic environment.

The objective of this research was to study heavy metal in sediment of El-Khadrawia drain, Menoufiya governorate using potential ecological risk index (PERI), sediment pollution index (SCI) and sediment quality guidelines. These indices will highlight the sediment contamination in terms of trace elements and evaluate the potential ecological risk.

2. MATERIALS AND METHODS

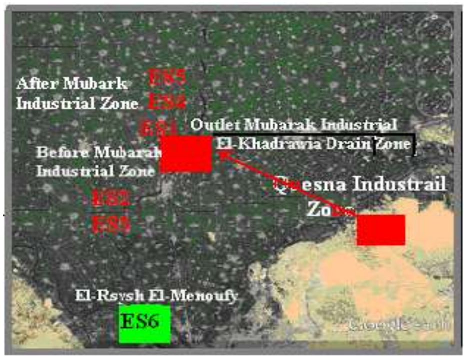
2.1 Study Area

El-Khadrawia drain starts in Menoufiya governorate passing districts including Brket El-Saba and Quesna ending in the Western Province center Zifta as located in the classification of the Ministry of Water Resources and Irrigation in Zifta as shown in Fig.(1). Quesna industrial zone include different industrial activities such as leather, foods, paper, coating, dyes and many other industries as shown in Fig.(1D). Some factories through self-investment development have constructed private sewer systems without wastewater treatment plant which dumped as raw sewage into left El-Khadrawia drain. Morever, Mubarak industrial zone is located on the left El-Khadrawia drain at km 19,600 until at km 29 of El-Khadrawia drain at the intersection of the drain with the Cairo-Alexandria agricultural road as shown in Fig.(1C). While El Rayah El Menoufy supplement from Rosetta Brach El Mansoura and Zifta cities, its length 170 Km **(Ghannam et al., 2015).** (Fig. 1B).

El-Rayah El Menoufy is about 170 Km in length, 50m width and 3 m depth that begins from El-Kanater El-khayria city - Rosetta Branch that crosses Monifia, Dakahlia and El Gharbiah governorates with maximum discharge 25 $M.m^3$/day **(Fathy et al., 2013)**. It expands into the middle of Delta, then direction north to south of Burullus Lake. El Rayah El Menoufy characterized by a number of small branches especially at Menoufiya governorate.

2.2 Sampling Program and Management

Samples: triplicate sediment layers of 0-20 cm are composed using a suitable stainless steel grab sampler from the bottom of El-Khadrawia drain that is affected by various anthropogenic activities (Qusena industrial zone discharge and industrial Mubark city) as shown in Fig. (1C), Fig. (1D) and El Rayah El Menoufy as demonstrated in Fig.(1B). The sediment samples were packed in a cooler bag during winter and summer seasons, stored in an ice box at 4^0C and transported to laboratory (Central Laboratory for Environmental Quality Monitoring, National Water Research Center “CLEQM-NWRC”) to be analyzed.



(A) **(B)**

(C) **(ES_1)** **(D)**

(E) - (ES_{2-3}) **(F) - (ES_{4-5})**

Fig.1 Study area showing sampling locations (ES_1, ES_{2-3}, ES_{4-5}& ES_6) along El-Khadrawia drain and El Rayah El Menoufy

The locations sited along El-Khadrawia drain as planned in Table (1). All preservations were taken to avoid samples impurity during sampling, drying, grinding, sieving and storage process.

Table (1) : Locations of sediment samples

locations	Code	Sampling Site	Longitude	Latitude	Pollution Source	Critical Risk
El-Khadrawia Drain	ES_1	Before Mubarak 2Km	30.497120	31.168011	Mubarak outlet	Impact of industries effluents
	ES_2	Before Mubarak 5Km	30.554558	31.146591	Mubarak outlet	for Mubarak + Industrial area
	ES_1	El-Khadraweya Drain	30.554558	31.189912	Mubarak outlet	Plastic, papers, feeds
	ES_4	After Mubarak 2Km	30.528020	31.191800	Industrial area	Metal industries paints, oils
	ES_5	After Mubarak 5Km	30.554558	31.189912	Mubarak + Industrial area	Feeds, bricks, rubber
El-Rayah El-Menoufy	ES_6	After El-Kanater-1Km	30.115985	31 644.97	non-polluted area	Control sample

2.3 Sampling Preparation

The collected samples were air-dried, grounded and sieved to give sediment with particle size < 2 mm, bulked up to get a composite sample for texture, organic matter and heavy metal concentrations using the standard procedures for each parameter.

2.4 Chemicals, Reagents and Instruments

Merck analytical grades (Darmstadt, Germany) of all reagents were used to prepare standard solutions and instrument calibration solutions under satisfying a clean laboratory environment. Liquid reagent (de-ionized and free organics) was used for stock standard solutions of multi trace elements (1000 mg/L) including Aluminum (Al), Barium (Ba), Boron (B), Chromium (Cr), Copper (Cu), Iron (Fe), Manganese (Mn), Lead (Pb) and Zinc (Zn) that measured using Inductively Coupled Plasma- Emission spectrometry (ICP-ES) with Ultra Sonic Nebulizer (USN) model Perkin Elmer optima 3000, USA. The samples were filtered through filtration system via membrane filter of pore size 0.45 um before analysis **(APHA, 2017)**.

2.4 Procedure of Sediment Characterization

Texture Analysis (TA)

Textural analyses of sediment samples was performed in soil laboratory to determine particles size distribution (PSD) through two steps as following:

- Step (1): Oxidization and heating were utilized to eliminate organic matter and calcium carbonate from air-dried sediment samples that were primarily pretreated with hydrogen peroxide 30% and diluted with 2N HCl acid.
- Step (2): Mechanical analysis (pipette method) was carried out as described by **Griffiths, 1951** and modified by **Carver, 1971** to determine texture by the texture triangle. The sediment texture was classified based on the mud content classification proposed by **Folk, 1954** and the modified classification by **Pejrup, 1988 and Fleming, 2000**.

Suspension extraction (decantation method)

Sediment samples were air dried at 25-35˚C to eliminate moisture until constant weight, grinded as described by **Folk, 1980** using sieving technique that collected through a 2 mm mesh, sealed in a clean plastic bags and equilibrated for 24 hours **(Bandyopadhyay et al., 2012 and State of Queensland, 2021)** for pH and trace elements analysis. Mixing 200 gm of sediment shaken with 1000 ml of de-ionized water (DI) in ratio (1:5) under laboratory conditions using a shaker model RUMO 3015 min to obtain suspension extract of sediment and then stand for 30-60 minutes. The extracts were spilted for two portions for pH analysis using WTW inolab pH level 1.

Microwave Digestion Technique

Digestion of sediment samples was carried out using microwave digestion techniques **(Clive et al., 2019)**. 3 ml of nitric acid , 3 ml of hydrofluoric acid and 2ml of hydrogen peroxide (Fisher 37% H_2O_2) were added to 0.5 gm of sieves sediment material into Teflon vessel of MILESTONE MLS – 1200 MEGA microwave digestion system with MDR (microwave digestion rotor) technology for 30 minutes. The De-ionized distilled water was added to digested samples, filtrated through filtration system via membrane filter of pore size of 0.45 um (ALBET® cellulose nitrate, gridded, sterile) and was completed to 100ml in a volumetric flask. The extracted solution was prepared for trace elements analysis.

Geochemical Analysis

Trace elements (Co, Pb, Al, Cd, Cr, Cu, Ni, Zn, Fe and Mn) were analyzed by Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) with Ultra Sonic Nebulizer (USN) model Perkin Elmer Optima 3000 according to the 3050B method **(EPA, 1996** and **APHA, 2017)**. The concentrations were recorded in mg/kg dry weight. The detection limit was <0.003 mg/kg for Co, Pb, <0.006 mg/kg for Al, <0.001 mg/Kg for Cd, Cr, Cu, Ni, Zn, <0.008 mg/Kg for Fe and <0.005 mg/Kg for Mn. In addition, accuracy and precision of analysis checked by replicate measurements of standard solution multi-elements 1000mg/l (Merck, Darmstadt German) and sediment samples were analyzed in five replicates and relative standard deviations (%RSDs) were less than 10% of the trace elements.

2.5 Statistical Analysis

Statistical analysis (ANOVA one-way) was used to estimate mean value, minimum value and maximum value which were reported when appropriate using IBM SPSS (Statistical Package for the Social sciences) Statistics 22 software package.

2.6 Pollution Assessment Method

There are many methods to quantify the degree of contamination in sediment comparing with the pre-industrial reference. Two indices discussed deposition and strength of heavy metals levels in sediment of El-Khadrawia Drain. These pollutants levels may have a toxic effect for bio-species and affect on food chain as serious problem on the microbiological balance of environment. The pollution indices are potential ecological risk index (PERI), sediment contamination index (SCI) and sediment quality guideline (SQG).

Potential Ecological Risk Index (PERI)

PERI evaluates the force of heavy metals on sediment environment through ecological analysis and categorized **(Liu et al., 2021)** into five classes as shown in (Table 2). Standard PERI index reflect toxicity classification for organic and inorganic eight contaminants that are PCBs, Hg, Cd, As, Pb, Cu, Cr and Zn. The present study used to the ranking standard of heavy metals' ecological risk indices based on the types and quantity of pollutants by previous studies for Cd, Pb, Cu, Cr and Zn **(Li et al., 2012, Zhu et al., 2013 & Zhang and Liu, 2014)** and PERI index can be deduced as follows formulas:

$$\mathbf{PERI} = \sum E^i_r \quad , \quad E^i_r = C^i_f \times T^i_f$$

Where

E^i_r: The potential ecological risk factor of single heavy metal pollution

C^i_f : The value of the concentration of heavy metal divided by the background value (Control sample).

T^i_f : The toxic factor of heavy metal, the values that are Cr and Zn (1), Cu and Pb (5), and Cd (30) **(Hakanson, 1980)**.

Table (2) : Grade standards for potential ecological risks

Grade	Risk Level	E^i_r	PERI
I	Low risk	< 30	< 100
II	Moderate	30–60	100–200
III	High	60–120	200–400
IV	Very high	120–240	> 400
V	Disastrous	> 240	> 400

Sediment Contamination Index (SCI)

Singh et al. 2002 assess sediment quality respect to heavy metal concentrations along metal toxicity using sediment contamination index (SCI) which is classified based on SCI contamination classification

As shown in Table 3, it can be expressed as:

$$\mathbf{SCI} = \sum(EF_m \times W_m) / \sum W_m \quad , \quad EF_m = C_n / C_R$$

Where

Cn: The concentration of analyzed metal

C_R: The background metal concentration (control sample)

W_m: Toxicity weight (Cr and Zn (1), Cu and Pb (5), and Cd (30)).

Table (3) – Classes of sediment contamination index

SCI Class	Pollution
0–2	natural sediment
2–5	low polluted sediment
5–10	Moderately polluted sediment
10–20	highly polluted sediment
>20	dangerous sediment

Sediment Quality Guideline (SQGs)

Bureau of Habitat, 2014 reported that sediment quality guidelines and mean ERM quotient are useful tools to assess possible risk, quality of sediments and provide acceptable concentrations of sediment bound pollutants to protect bio-species living in or near the sediments **(Zhao et al., 2014)**.

The investigated metal concentrations were measured up to the numerical sediment quality guidelines that are effect range low (ERL) and effect range median (ERM) **(MacDonald et al., 2000** and **Long et al., 2006)**, severe effect level and (SEL) **(Persuad et al., 1993)** as tabulated in Table (4).

The work balance land sediments with Canadian soil quality guidelines (CSQG) of Canadian Council of Ministers of the Environment **(CCME, 2001)** as listed in Table (4).

Table (4) – Sediment guidelines standards for metals(mg kg^{-1})

Guidelines	Cd	Cr	Cu	Co	Fe	Mn	Pb	Zn	Ni
CCME, 2001	1.4	64	63	40	-	-	70	200	50
ERL	1.2	81	34	-	-	-	46.7	150	20.9
ERM	9.6	370	270	-	-	-	218	410	51.6
SEL	10	110	-	-	4000	1100	-	-	-
Average	6.91	28.85	536.21	6.1	31948	935.8833	34396.17	372.83	95.21667

3. RESULTS AND DISCUSSION

3.1 Disturbing Factors

Texture of sediment is an important factor that shows the increase trend of clean water body from the upstream to downstream while pollution sources is usually shows a decrease trend of contaminated water body by dilution. Based on the monitoring data of sediment quality in the study area, quantitative analysis of trace elements contamination in sediment from the bottom of El-Khadrawia drain was piloted using three indexes.

These indexes demonstrated their standards the differe significantly among toxic trace elements that affected by anthropogenic sources in terms of wastewater discharges, agricultural and urban activities **(Gulten Gunes, 2021)**.

3.2 Sediment Properties and Classification

Mechanical methods for six samples of investigated sites provided the distribution of dissimilar sizes of sediment particles and wrere classified into coarse fragments, gravel, sand, silt and clay which is demonstrated in Fig.(2).

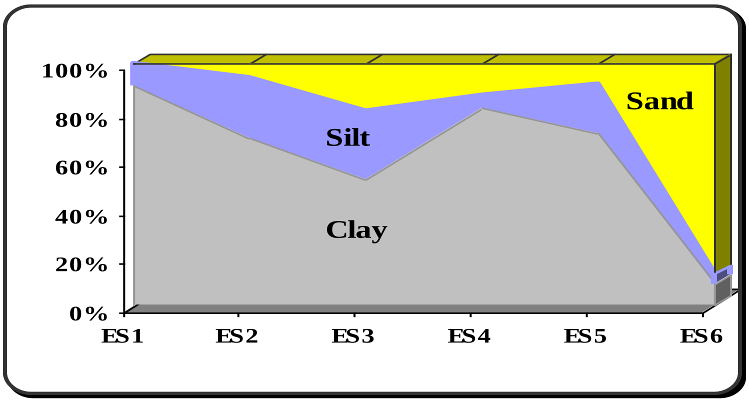


Fig.(2) PSD of sediment samples along El-Khadrawia drain and El-Rayah El-Menoufy

The data showed the sites that have two different shelf grain sizes, of clay, loamy and sand particles. Clay layer can be adsorb water, inorganic ions, organic matter and gases on their surfaces as storage of pollutants as shown in Fig. (2). Figure (3) showed the clarification of textural composition of all sites that was clay except El-Rayah El-Menoufy, as Control sample (El-Kanater El-Khayria) were loamy sandy and they did not have the ability to adsorb any components.

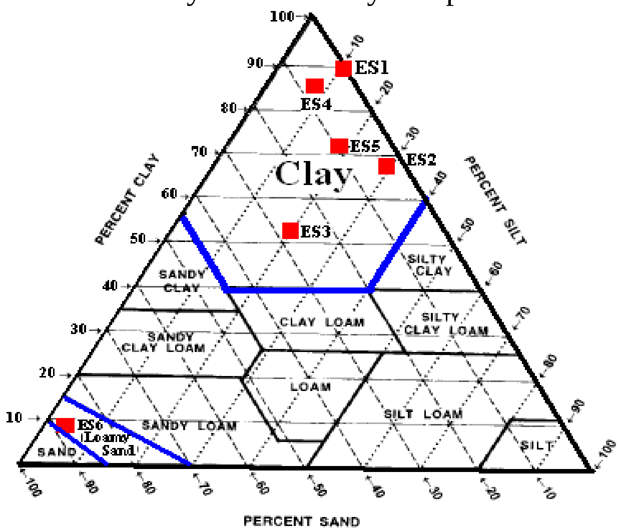


Fig. (3) Classification of sediment along study area (El-Khadrawia drain and El-Rayah El-Menoufy)

3.3 Assessment of Heavy Metal Contamination

pH value of sediment was generally divided into five categories that are slightly acidic (pH < 5.0), mildly acidic (5.0 - 6.5), neutral (6.5 - 7.5), mildly alkaline (7.5 - 8.5) and the strongly alkaline (pH > 8.5). pH values of studied samples ranged from 8.19 to 8.79 which implicit a gradual mildly alkaline and the trend of pH is similar along environmental sampling. The average of pH values in El-Khadrawia drain and El-Rayah El-Menoufy samples was 8.4 showing a mildly alkaline property (Fig. 3). Many procedures by researches have been used to assess heavy metal contamination in sediment to understand anthropogenic activities ability, variation the concentrations of potentially toxic metals to aquatic life and ecology inference.

Table (5) and Fig. (4) summarize the minimum, maximum, and average concentrations (mg kg^{-1}) of ten heavy metals in bottom sediment samples collected from El-Khadrawia drain and El-Rayah El-Menoufy. The concentration of ten heavy metals were Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn ranged in 411-53490, <0.001-10.7, <0.005-10.7, 1.1-48.2, 7.8-770.8, 611-48330, 1.2-979.1, <0.001-196.3, 6.54- 50660 and 1.4-611.5 mg kg^{-1}, respectively.

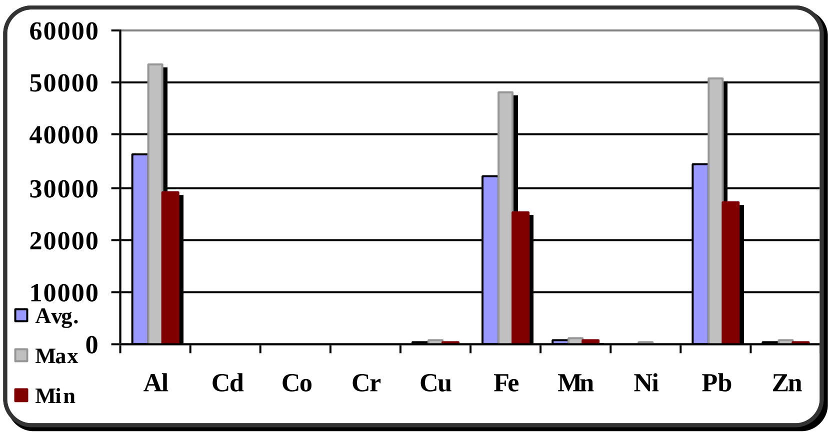


Fig. (4) Average, max. and min. concentration of heavy metals in sediment along study area (El-Khadrawia Drain) (mg kg^{-1})

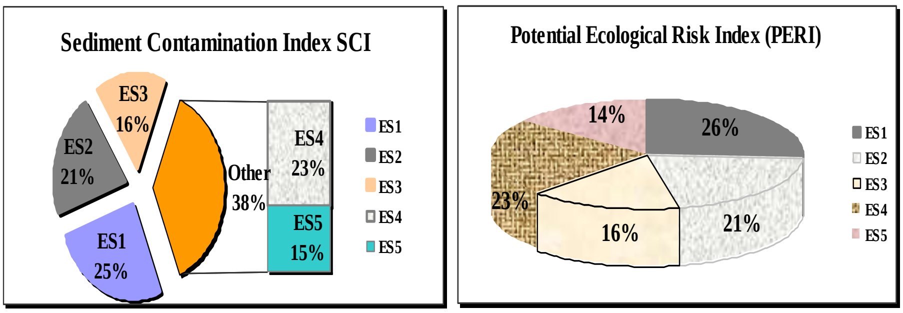
The average concentration ranked in a descending order , where Al (36534.67 mg kg^{-1})> Cd (34397.26mg kg^{-1})> Zn (32049.83mg kg^{-1})> Ni (936.083mg kg^{-1})> Cu (537.513 mg kg^{-1})> Co (373.06mg kg^{-1}) > Cr (95.2166mg kg^{-1}) >Mn (29.03 mg kg^{-1}) > Pb (6.91 mg kg^{-1})> Fe (6.1mg kg^{-1}). However, heavy metals concentrations of ten heavy metals along El-Khadrawia drain were higher than background values of study area.

Table (5): Concentration of heavy metals (mg kg^{-1}) in the sediment of El-Khadrawia drain and El-Rayah El-Menoufy

	Investigated Site						
Heavy Metal	ES_1	ES_2	ES_3	ES_4	ES_5	Avg.	El-Rayah (control sample)
Al	53490	45930	40953	49482	28942	36466.17	411
Cd	10.7	8.7	6.56	9.6	5.9	6.91	<0.001
Co	9.2	4.2	3.8	10.7	8.7	6.1	<0.005
Cr	48.2	32.8	28.3	38.9	24.9	28.85	1.1
Cu	770.8	687.01	476.07	701.7	581.7	536.21	7.8
Fe	48330	33404	25334	44310	40310	31948	611
Mn	979.1	799.1	675.1	1831	1331	935.8833	1.2
Ni	196.3	169.3	109.9	60.4	35.4	95.21667	<0.001
Pb	50660	45066	27011	48820	34820	34396.17	6.54
Zn	611.5	551.15	475.15	353.1	246.1	372.83	1.4

Toxicity characteristics for heavy metals

Sediment Contamination Index (SCI) evaluate sediments pollution according to toxicity characteristics for six heavy metals that are Cr, Zn, Cu, Ni, Pb and Cd **(Banu et al., 2013 and Pejman et al., 2015)** of El-Khadrawia drain. The index revealed El-Khadrawia drain sediments as a dangerous polluted at all sites of drain (5Km on beside of outlet Mubark industrial zone) and naturally at El-Rayah El-Menoufy. Figure 5A destructive the SCI percentages for investigated sites in order ES_1 (25%)> ES_4 (23%)>ES_2 (21%)> ES_3 (16%)> ES_5 (15%) and for El-Rayah El-Menoufy. The spatial distribution of heavy metals was site-specific; demonstration a extremely high level in the sampling locations with intense of agricultural activities (El-Khadrawia drain) and industrial activities (outlet Mubark and Quesna industrial zones) that agree with **Fang Shen et al., 2019** for identification and assessment of heavy metals source.



(A) **(B)**

Fig. (5 A-B) Distribution of toxicity characteristics using SCI and PERI for heavy metals along El-Khadrawia drain

Potential Ecological Risk Index (PERI) for aquatic pollution control is an analytical tool to sort out which site-specific should be given special attention. The results showed the potential ecological risk factor of single metal (E^i_r) for heavy metals risks ranking in the following order Cd (248760)> Pb (23839.91)> Cu (147.844)> Zn (319.5)> Cr (34.62) as listed in Table (6) and Fig.(5B).

Table (6): Broad potential ecological risk index (PERI)

	E^i_r (potential ecological risk factor)				
	Cr	**Zn**	**Cu**	**Pb**	**Cd**
Average	**34.62**	**319.5**	**147.844**	**23839.91**	**248760**
Maximum	**48.2**	**436.7**	**179.92**	**37324.1**	**321000**
Minimum	**24.9**	**175.7**	**111.96**	**150.07**	**177000**
	ES_1	**ES_2**	**ES_3**	**ES_4**	**ES_5**
PERI	**360409**	**296053.6**	**217937.7**	**325791.6**	**203968.2**

According to the grading standards of the PERI index indicated that there were high potential risks (PERI) for each single metals at all sites ES_1 (360409)> ES_4 (325791.6)> ES_2 (296053.6)> ES_3 (217937.7)> ES_5 (ES_5) in each sediment sample along El-Khadrawia drain as demonstrated in Fig.(5B) and Fig.(6).

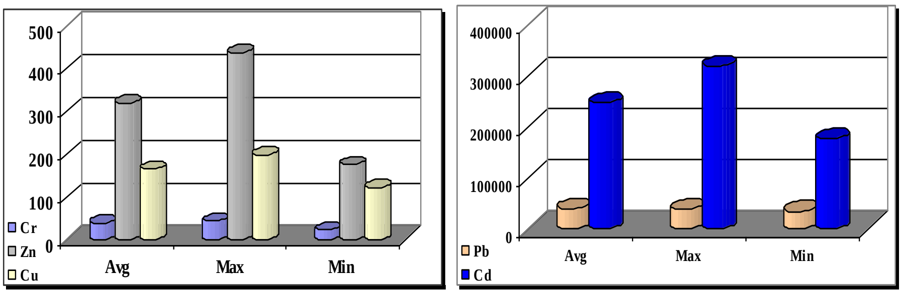


Fig.(6) Potential Ecological Risk of Heavy Metals El-Khadrawia Drain

3.4 Sediment Quality Guideline (SQGs)

Council of Ministers of the Environment Quality Standard for Sediment (CSQGs - mg/Kg dry weight) standards contain three effects value, namely, effect range low (ERL) which determine values indicative of concentrations below which adverse biological effects such as toxicity to biota rarely occur, effect range medium (ERM) which determine values representive of concentrations above which adverse biological effects frequently occur and severe effect level (SEL) which indicates alevel of contamination to the majority of sediment-dwelling organisms **(CCME, 2001)**.

Criteria Designed of Internationally Traditional Canadian Council - Ministers of the Environment quality standards for Sediment (SQGs -

mg/kg dry weight) is selected to assess sediment quality and the ecological risks **(Ali et al., 2016; Zarezadeh et al., 2017 and Birch et al., 2018)** associated with heavy metals: Cd, Cr, Co, Zn, Ni, Cu, Fe and Mn as presented in Table (7).

Table (7) Descriptive study of sediment quality (CCME, 2001)

Metal	ES_1	ES_2	ES_3	ES_4	ES_5	ES_6	CSQGs Standard				
							limit	ERL	ERM	SEL	Adverse Effect (%) <ERL Middle >ERM
Cr	48.2^{ac}	32.8^{ac}	28.3^{ac}	38.9^{ac}	24.9^{ac}	1.1^{a}	64	81	110	370	2.90 21.1 95.0
Zn	611.5^{bc}	551.15^{bc}	475.15^{bc}	353.1^{bc}	246.1^{bc}	1.4^{a}	200	150	410	---	6.10 47.0 69.8
Cu	770.8^{bc}	687.01^{bc}	476.07^{bc}	701.7^{bc}	581.7^{bc}	7.8^{a}	63	34	270	---	9.40 29.1 83.7
Ni	196.3^{bc}	169.3^{bc}	60.4^{bc}	109.9^{bc}	35.4^{ab}	$<0.001^{a}$	50	20.9	51.6	---	----- ----- -----
Pb	50660^{bc}	45066^{bc}	27011^{bc}	48820^{bc}	34820^{bc}	6.54^{a}	70	46.7	218	---	8.00 35.8 90.2
Cd	10.7^{bd}	8.7^{bc}	6.56^{b}	9.6^{bc}	5.9^{b}	$<0.001^{a}$	1.4	1.2	9.6	10	----- ----- ----
Fe	48330^{d}	33404^{d}	25334^{d}	44310^{d}	40310^{d}	611	---	---	---	4000	----- ----- ----
Mn	979.1	799.1	675.1	1831^{d}	1331^{d}	1.2	---	---	---	1100	----- ----- ----

(a) The range and of heavy metals concentrations (mg/kg) in El-Khadrawia Drain and El-Rayah El-Menoufy lower than CSQGs limits, (b) The heavy metal concentrations in El-Khadrawia Drain and El-Rayah El-Menoufy more than CSQGs limits and ERL limits, (c) The heavy metal concentrations more than ERM of CSQGs, (d) The heavy metal concentrations more than SEL of CSQGs

Table (7) showed the possible toxicological significance of chemical concentrations in sediments to rank and prioritize sites chemical concern. Samples, in which ERL concentrations are exceeded but no ERM are exceeded, might be given intermediate ranks. Samples in which the ERM values are exceed by a large degree may be considered as more contaminated than those in which none of the SQGs values are exceeded. Samples in which the ERM values are exceed which is the level of contaminate concentration in sediment that could potentially eliminate most of the benthic organisms and hazard water quality or human health.

Comparison of measured concentrations (mg/kg - dry weight) of various contaminants within the sediments with these guideline values provides a basic indication of the degree of contamination on ecology. Table (7) clarified the concentration of Cr, Cu, Fe, Ni, Pb, Zn, Cd and Mn in the present study that did not exceed the ERL values for El-Rayah El-Menoufy which had 0-% incidence of adverse biological effect.

Figure (7 A-H) clarified the occurrence (%) of adverse biological effects in concentration ranges that defined by ERL, EML and ESL values of sediment quality guidelines (CSQGs) for heavy metals that have been investigated. Four heavy metals: Zn (11-27%) (Fig. 7 F), Cu (15-70%) (Fig. 7 B), Ni (6-34%) (Fig. 7 D) and Pb (13-24%) (Fig. 7 E), concentrations had exceeded the ERM values that represented as incidence of adverse biological affects and pose special threats on organisms in the area.

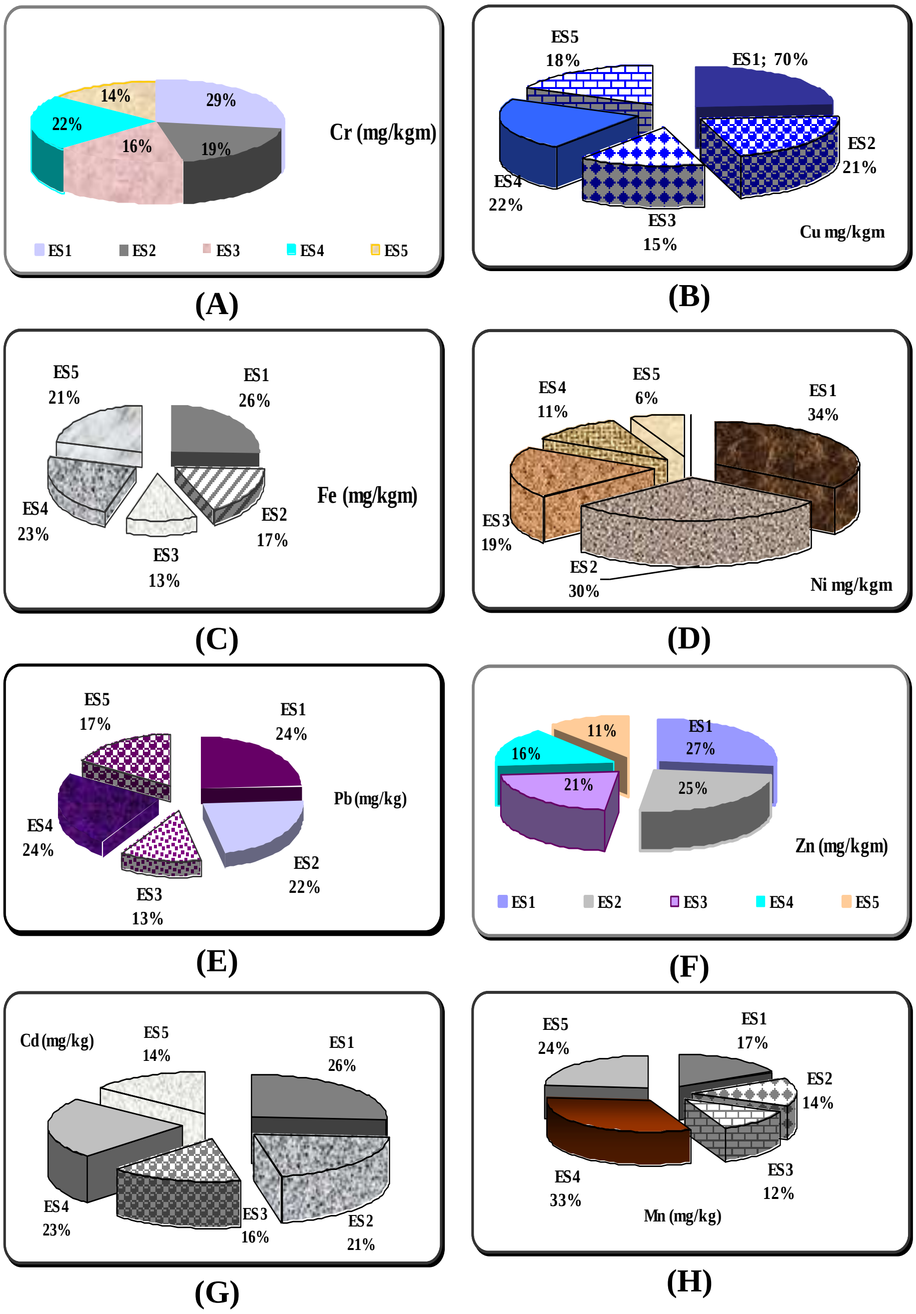


Fig. (7): Heavy metals concentrations percentage of CSQGs standards along El-Khadrawia drain and El Rayah El Menoufy

Cadmium concentrations had various adverse biological effects along El-Khadrawia drain which ES_2 (21%), ES_3 (16%), ES_4 (23%) and ES_5 (14%) had exceeded ERM values while ES_1 (26%) exceeded ESL values. Also, manganese recorded variables adverse biological effects along El-Khadrawia drain which ES_1 (17%), ES_2 (12%) and ES_3 (12%) did not exceeded ESL values while ES_4 (33%) ES_5 (24%) exceeded ESL values indicating that this metal may cause an adverse effect on the biota community.

Finally, iron recorded very high concentrations exceeded ERS values (ERS: 4000 mg/Kg) for all studied samples along El-Khadrawia drain that represented 13-26% incidence of adverse biological effects: ES_1 (26%), ES_2 (17%), ES_3 (13%), ES_4 (23%) and ES_5 (21%) had exceeded ERM values.

4. CONCLUSION

It is found clearly that the heavy metals pollution in sediments along El-Khadrawia drain and El-Rayah El-Menoufy were found by utilizing SCI and PERI indices. It is more provide significant data for making choices will protect and enhance the biological community. The concentration of ten heavy metals that were Al, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn ranged in 411-53490, <0.001-10.7, <0.005-10.7, 1.1-48.2, 7.8-770.8, 611-48330, 1.2-979.1, <0.001-196.3, 6.54- 50660 and 1.4-611.5 mg kg^{-1}, respectively.

CSQG guidelines clarified occurrence (%) of adverse biological effects in concentration ranges defined by ERL, ERM and ESL values of sediment quality guidelines (CSQGs) for heavy metals that have been investigated. The fixation from the data, Fe surpassed ERL worth for all studied samples and others were variables which four heavy metals: Zn (11-27%), Cu (15-70%), Ni (6-34%) and Pb (13-24%) concentrations had exceeding the ERM values that represented incidence of adverse biological affects and pose special threats on organisms in the area. Cadmium and manganese concentrations had various adverse biological effects along El-Khadrawia drain that may cause an adverse effect on the biota community. Furthermore, the study showed that, sediment samples were highly polluted to danger related to different anthropogenic sources activities and human wastes.

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تقييم نسبة التلوث ومخاطر السمية البيئية للمعادن الثقيلة في الرسوبيات على طول مصرف الخضراوية

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المركز القومى لبحوث المياه

يتعرض مصرف الخضراوية لعدد من الأنشطة البشرية مثل صيد الأسماك والري وصرف المنطقة الصناعية بقويسنا وكذلك مدينة مبارك الصناعية مما يشكل خطرا كبيرا علي طبيعة الرسوبيات على طول المصرف وذلك لوجود تركيزات عاليه من المعادن الثقيلة في صرف تلك المناطق الصناعيه مما يؤثر سلبا علي البيئه الاقتصاديه.

يهدف هذا البحث الي إجراء التحليل الميداني والمعملي لتقييم مستوى التلوث والمخاطر البيئية المحتملة على طبيعة الرسوبيات على طول مصرف الخضراوية.

وعلـــى ذلـــك فقـــد تـــم جمـــع ســـتة عينـــات مـــن الرســـوبيات فـــي ثـــلاث طبقـــات مـــن الرواســـب علـــى طـــول مصـــرف الخضـــراويه وتـــم عمـــل توصـــيف للخصـــائص الكيميائيـــة للرســـوبيات وكـــذلك تـــم عمـــل التحليـــل الجيوكيميـــائي للســـموم البيئيـــة باســـتخدام دليـــل جـــودة الرواســـب (SQGs) ، ومؤشـــر تلـــوث الرواســـب (SCI) ومؤشـــر المخـــاطر البيئيـــة المحتملـــة (PERI) لتحديـــد نســـبة تركيـــز العناصـــر الثقيلـــه مثـــل الألمنيـــوم: (Al) ، النيكـــل (Ni) ، الحديـــد (Fe) ، المنغنيـــز (Mn) ، الكوبالـــت (Co) ، الكـــادميوم (Cd) ، الكـــروم (Cr) ، الزنـــك (Zn) ، النحـــاس (Cu) و كـــذلك الرصـــاص (Pb) فـــي عينـــات الرســـوبيات علـــى طـــول مصـــرف الخضراوية وكذلك الرياح المنوفي لتقييم وتوقع المخاطر البيئيه المحتمله.

وقـــد اظهـــرت نتـــائج البحـــث أن نســـبة تركيـــز جميـــع المعـــادن الثقيلـــه (ماعـــدا الكـــروم) فـــي جميـــع عينـــات الرســـوبيات التـــى تـــم جمعهـــا قـــد تعـــدت الحـــدود المســـموح بهـــا وذلـــك وفقـــا للحـــدود القياســـيه الكنديـــه لنوعيـــة الرســـوبيات (SQGs) وقد كان لها تأثير منخفض على الحياه البيولوجيه للكائنات الحية.

وقـــد أفـــاد مؤشـــر تلـــوث الرواســـب (SCI) ومؤشـــر المخـــاطر البيئيـــة المحتملـــة (PERI) أن جميـــع عينـــات الرســـوبيات التـــى تـــم جمعهـــا تحتـــوى علـــي نسبه عاليه من التلوث بالعناصر الثقيله.