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SOIL QUALITY INDEX AT PASIR GUDANG INDUSTRIAL AREA

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Graphical abstract

Abstract

Soil Quality Index (SQI) is a very useful and efficient method for assessing the quality of soil. It is a useful tool for obtaining information on overall quality of soil. Five soil attributes namely acidity (pH), Organic Matter (OM), Phosphorus (P), Potassium (K), and Electrical Conductivity (EC), have been combined to construct an index to represent the soil quality. Location characteristics were observed during the time of sampling, and it was categorized according to industrial, riverside residential and educational area. From the determination of heavy metals concentration, certain area especially nearby Pasir Gudang industry has recorded heavy metal concentration exceeded the world average value for a few types of heavy metal. Soil quality index at Sg Kim Kim recorded poor quality index whereas the other locations indicated good to average soil quality index.

Keywords: Soil quality index, heavy metal, soil contamination, industry, major concentration

Abstrak

Indeks Kualiti Tanah (SQI) adalah kaedah yang sangat berguna dan cekap untuk menilai kualiti tanah. Ia adalah alat yang berguna untuk mendapatkan maklumat tentang kualiti keseluruhan tanah. Lima sifat tanah iaitu keasidan (pH), Bahan Organik (OM), Fosforus (P), Kalium (K), dan Kekonduksian Elektrik (EC), telah digabungkan untuk membina indeks bagi mewakili kualiti tanah. Ciri-ciri lokasi diperhatikan semasa masa pensampelan, dan ia dikategorikan mengikut kawasan perindustrian, kawasan perumahan tepi sungai dan pendidikan. Daripada penentuan kepekatan logam berat, kawasan tertentu terutamanya Kawasan yang berhampiran industri Pasir Gudang telah mencatatkan kepekatan logam berat melebihi nilai purata dunia bagi beberapa jenis logam berat. Indeks kualiti tanah di kawasan Sg.Kim Kim mencatatkan indeks kualiti rendah manakala lokasi lain menunjukkan indeks kualiti tanah baik hingga purata.

1.0 INTRODUCTION

Global industrial output is expected to continue to grow as is illustrated by the chemical sector (Cayuela and Hagan, 2019). The use of chemicals, other than pharmaceuticals, is projected to increase by 85 percent by 2030, with China and the European Union remaining the largest consumers. Although anthropogenic chemicals have delivered enormous benefits to human civilization, these are offset by large-scale negative impacts, resulting from unintentional human and environmental exposure and toxicity. According to survey demonstrate studies by (Ehsanul et al, 2012), the metal concentrations in soil generally reflect the influence of various local industrial activities which include metal and mining, chemical and petrochemical, textile, leather, cement, and ceramic industries. Then, observations of generally enhanced metal levels in soils around various industrial facilities are explainable by unregulated, untreated solid and fluid wastes released by the industries to the nearby land. (Shelan and Nashmeel, 2015) concluded that, the detected heavy metal contents are introduced by so many sources, proximity to the main roads and human activities in the industrial area. Industrial areas have been implicated for elevated concentration of Lead (Pb), Copper (Cu), Zinc (Zn) and Nickel (Ni) in soils as well as spent oil residues and relative pollution potential for these pollutants indicated that the soils were contaminated at the point of impact, but the metal levels are still below the maximum acceptable levels described by EPA, and they are non-toxic to human health. According to a study conducted by (Elias et al, 2017) in Gebeng, most of the elements in soil samples are detected using Neutron Activation Analysis (NAA) technique. Pollution index (PI) was applied to the data set to discover possible sources that might influence different distribution of elements over study area around Perlis (Siti et al, 2014) and found that level of heavy metal in soil near centralized Chuping industrial areas give maximum value compared to other location in Perlis. On the other hand, (Ain et al, 2018) found the corresponding result to (Siti et al, 2014) study, where the concentration heavy metal in soil near Chuping industrial area gives maximum values compare with other location in Perlis.

Due to its proximity to numerous sectors, including shipping, petrochemicals, other heavy industries, oil palm storage and distribution, transportation and logistics, and shipbuilding, the Straits of Johore are seen as a hotspot location for possibly receiving a lot of anthropogenic inputs. An industrial town called Pasir Gudang in the Johor Bahru district has gained notoriety as a result of chemical waste contamination in the Kim Kim River. It is situated close to the Straits of Johore's eastern coast. The most well-known industrial city in Johor is Pasir Gudang, which is situated east of Johor Bahru. Transport and logistics, shipbuilding, and petrochemical are the main sectors connected to Pasir Gudang because of its location by the Straits of Johor. Heavy businesses including palm oil distribution and storage are also practiced in the region. Due to its hotspot as pollution sources in Malaysia, the Straits of Johore have been constant investigated and monitored in particular for heavy metal pollution by using surface sediments.

2.0 METHODOLOGY

2.1 Study area, soil sample collection and testing

The standard depth of topsoil samples (0–20 cm) were taken at 20 sites in Pasir Gudang Johor (Figure 1). Table 1 lists the locations used for sampling. A stainless-steel shovel was used to gather around 2 kg of topsoil from each sampling site. The samples were put in zipped-lock polyethylene bags. The soil samples were brought to the laboratory, oven-dried at 105 °C for 24 hours, and then sieved through a 2 mm nylon mesh to remove any foreign particles. To completely dissolve in the acid digestion of the soil particles for heavy metal analysis, the dried soils were passed through 63 µm sieves. This was because the highest metal concentrations, such Lead (Pb). Location's characteristics were observed during the time of sampling, and it was categorized according to industrial, riverside residential, and educational area. Then, all selected sampling sites were divided into several groups where (sites A: the centre of the industry area), (sites B: 7 kilometers away from the centre of the industry), (sites C: 12 kilometers away from the centre of the industry), (sites D: 14 kilometers away from the centre of the industry), and (sites E: 21 kilometers away from the centre of the industry).

The industrial area's sampling sites were surrounded by heavy industrial activities. Therefore, four (4) point number use in Pasir Gudang and Tanjung Langsat is mainly considered as industrial categories. Three (3) riverside area were chosen in this study to monitor the soil contaminated. The selected location was Sg Rinting, Sg Masai Lama and Sg Kim Kim Pasir Gudang. Other than that, Sek Keb Kg Pasir Putih, Politeknik Scientex and UiTM Pasir Gudang were three (3) sampling sites locations under categories educational area. In this study, UiTM Pasir Gudang was the most distant location compared to other two (2) educational area locations and its approximately around 21 kilometers distance. For the residential area, the ten (10) sites have observable residential housing at proximity with four various distances from the centre of the industry area. Taman Bukit Dahlia, Tg. Puteri Resident and Eco Tropics were located 7 kilometers and its close vicinity to the centre of the Pasir Gudang industry area. These three residential areas were considered very closed to industrial area compared to other locations and can be consider as high-risk residential area. Pasir Putih and Nusa Damai were located 12 kilometers while Taman Rinting and Flora Heights approximately 14 kilometers away from the centre of the Pasir Gudang industry area. Lastly, Megah Ria, Senibong Cove, and Bandar Seri Alam were located 21 kilometers far away from the centre of Pasir Gudang. The test method for soil testing complied to USEPA 3050B, MS2457:2012 and DUMAS method.

Figure 1 Sampling sites in Pasir Gudang Johor

Table 1 Details lists of sampling site locations.

Sampling Sites	Point No	Coordinate	Distance From Centre Industry PG/ Tg Langsat
Industry PG 1	1	1°26'40.1"N 103°54'30.6"E	7 Km
Industry PG 2	2	1°27'22.6"N 103°53'05.6"E	7 Km
Industry PG 3	10	1°27'34.5"N 103°54'25.6"E	Centre Pg
Industry PG 4	14	1°28'10.4"N 103°58'22.0"E	Centre Tg Langsat
Sg Rinting	3	1°28'42.2"N 103°52'36.0"E	12 Km
Sg Masai Lama	8	1°29'12.7"N 103°52'53.3"E	12 Km
Sg Kim Kim	13	1°27'35.7"N 103°57'24.5"E	7 Km
Tmn Rinting	4	1°29'18.7"N 103°52'16.4"E	14 Km
Megah Ria	5	1°29'56.6"N 103°51'03.2"E	21 Km
Senibong Cove	6	1°29'22.1"N 103°50'29.2"E	21 Km
Bdr Seri Alam	7	1°30'27.9"N 103°51'06.3"E	21 Km
Tmn Bukit Dahlia	9	1°29'00.9"N 103°53'46.0"E	7 Km
Tg Puteri-Resident	12	1°27'13.9"N 103°56'04.8"E	7 Km
Pasir Putih	15	1°27'46.7"N 103°56'47.4"E	12 Km
Eco Tropics	16	1°28'42.2"N 103°56'02.0"E	7 Km
Nusa Damai	17	1°30'05.4"N 103°54'33.8"E	12 Km
Flora Heights	18	1°30'35.3"N 103°53'51.6"E	14 Km
Sek Keb Kg Pasir Putih	11	1°26'09.6"N 103°55'53.5"E	12 Km
Politeknik Scientex	19	1°29'48.5"N 103°54'53.1"E	12 Km
Uitm Pasir Gudang	20	1°31'37.0"N 103°52'38.3"E	21 Km

2.2 Soil Quality Index (SQI)

Soil Quality Index (SQI) is a very useful and efficient method for assessing the quality of soil (Brejda and Thomas, 2001). It is a useful tool for obtaining information on overall quality of soil. Five soil attributes namely acidity (pH), Organic Matter (OM), Phosphorus (P), Potassium (K), and Electrical Conductivity (EC), have been combined to construct an index to represent the soil quality.

SQI = (DpH + DOM + DP + DK + DEC) / 5
D pH = 1 if pH > 6.5 and 0 otherwise
DOM = 1 if OM > 2 and 0 otherwise
DP = 1 if P > 20 and 0 other wise
DK = 1 if K > 80 and 0 otherwise
DEC = 1 if EC < 2 and 0 otherwise

The Soil Quality Index (SQI) is computed for all samples of the study area. SQI is bounded between 0.1 to 1 and the higher the SQI the better the quality of soil. Based on the SQI values, the soil quality scale is rated as good (>0.7), average (0.5 – 0.7) and poor (0 .1 – 0.4).

3.0 RESULTS AND DISCUSSION

3.1 Heavy metals and Major Concentration

Table 2 shows heavy metal concentration in soil at Pasir Gudang industrial area. The concentration of cadmium, Cd was below detection limit at all point locations. Arsenic and lead were below detection limit at certain locations. The concentration of phosphorus, potassium, copper, chromium, nickel, zinc and lead ranged from 9.06 to 172 mg/kg, 120 to 436 mg/kg, 2.5 to 23.78mg/kg, 4.49 to 20.74, 1.31 to 23.44mg/kg, 3.33 to 88.73mg/kg and 1.67 to 13.3 mg/kg respectively. In the subsoil samples, the concentration of the heavy metals followed the order k>P>Zn>Cu>Ni>Cr>Pb.

When the concentration of the heavy metals is compared with the background values provided by Taylor and McLennan, 1995 and the world soil average given by Kabata-Pendias, 2011 at Table 2. The concentration of Zinc, Zn is above the world average value as well as upper continental crust at three (3) points (2, 5 and 14). The concentration of Nikel, Ni exceed the world average value as well as upper continental crust at point no. 18. This area nearby palm oil field whereby the fertiliser is used to plant the palm oil. Higher concentration of phosphorus, P was found at point nos. 2,3,5 and 14. Point no. 14 has 3 heavy metals exceed limitation, followed by point nos. 2 and 5. The other places are lower than the world average value as well as upper continental crust.

Table 2 Concentration of heavy metals (Kabata-Pendias , 2011)

Parameter	Unit	MIN	MAX	Upper continental crust	World average
Phosphorus, P	mg/kg	9.06	172		
Potassium, k	mg/kg	120	436	28000	16900
Copper, Cu	mg/kg	2.5	23.78	25	38.9
Chromium, Cr	mg/kg	4.49	20.74	35	59.5
Nickel, Ni	mg/kg	1.31	23.44	20	29
Zinc, Zn	mg/kg	3.33	88.73	71	70
Lead, Pb	mg/kg	1.67	13.3	20	27
Cadmium, Cd	mg/kg	0	0		
Arsenic, As	mg/kg	0.02	0.06		

3.2 Soil Quality Index (SQI)

The Soil Quality Index (SQI) is computed for all samples of the study area as shown in Table 3 and Figure 2. SQI is bounded between 0.1 to 1 and the higher the SQI the better the quality of soil. Based on the SQI values, the soil quality scale is rated as good (>0.7), average (0.5 – 0.7) and poor (0 .1 – 0.4).

Table 3 Detail Data of Soil Quality Index

Para-meter	MC	Acidity	Organic	Phos-phorus	Potassium	Conductivity	SQI	Indicative
Point No	%	-	%	mg/kg	mg/kg	µs/cm		
1	20.48	7.3	4.65	59.14	255	45	0.8	Good
2	26.24	6.3	5.73	91.45	120	54	0.6	Average
3	47.96	6.9	7.84	169	436	1013	0.8	Good
4	17.58	8.1	8.96	41.39	436	100	0.8	Good
5	34.09	7.7	10.68	172	121	60	0.8	Good
6	20.87	6	6.84	33.47	205	27	0.6	Average
7	12.75	6.8	9.55	43.67	147	47	0.8	Good
8	12.82	7	8.47	126	158	33	0.8	Good
9	22.07	5.5	7.14	59.25	197	16	0.6	Average
10	13.48	6.2	5.85	57.74	149	40	0.8	Good
11	21.07	5.4	4.85	67.65	150	66	0.6	Average
12	23.14	6.8	8.31	50.46	340	29	0.8	Good
13	19.63	6.9	1.1	9.06	254	13	0.4	Poor
14	14.12	7.6	5.12	73.67	202	49	0.8	Good
15	16.94	6.7	5.27	13.62	208	31	0.8	Good
16	12.95	7.9	6.1	49.82	274	80	0.8	Good
17	31.70	7.8	9.13	14.57	174	62	0.6	Average
18	22.00	5.8	7.91	27.76	148	36	0.6	Average
19	31.94	6	6.67	43.52	281	38	0.6	Average
20	2.90	5.3	12.5	49.96	245	34	0.6	Average

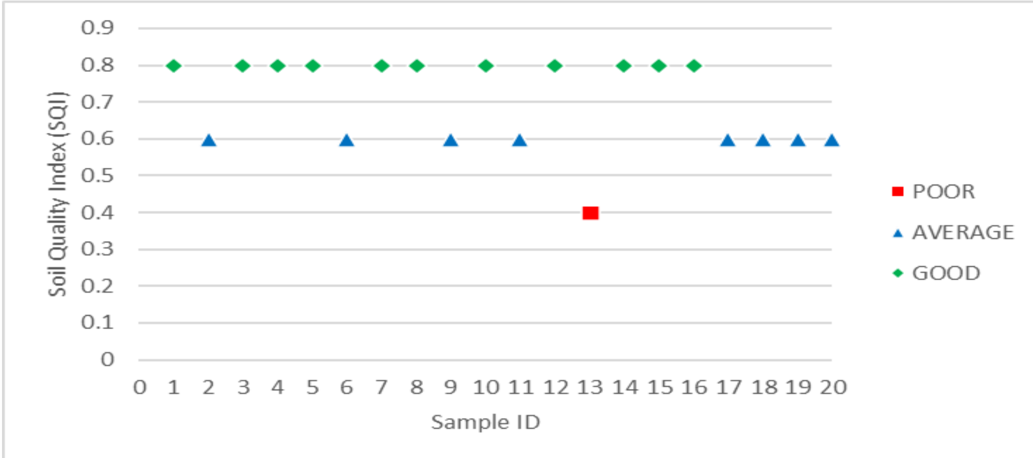

Figure 2 Soil Quality Index

4.0 CONCLUSIONS

Soil samples were taken at Pasir Gudang industrial area for heavy metals concentrations determination. Based on the concentration of heavy metals recorded at this area, most of area recorded the concentration below the world average value and upper continental crust. Only certain area especially nearby Pasir Gudang industry has recorded the heavy metal concentration exceeded the world average value for a few types of heavy metal. Soil quality index at this area indicated that only one location which is Sg. Kim Kim recorded poor quality index whereas the other locations indicated good to average soil quality index. From this study it can be concluded that the management of pollution control at Pasir Gudang industrial area has been properly implemented. However further study can be done for different and more locations at this area.

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