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A COMPARATIVE ANALYSIS OF ENVIRONMENTAL QUALITY ASSESSMENT METHODS FOR HEAVY METAL-CONTAMINATED SOILS

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ABSTRACT

The environmental quality of eight soils at a contaminated heavy metal factory was assessed using four evaluation methodologies. To analyze outcomes, the full index model is more reasonable than the one-factor index method. Membership features have been used in dynamic mathematical ways to determine the limits between different pollution classes, and pollutant contributing variables have been found using weights, in contrast to the pollution index. In the single-factor approach, the dominant feature was highlighted more, while the effects of the other elements were decreased. However, in the weighted average model, each element contribution was thoroughly investigated, and weights were assigned based on the level of contribution. Membership functions were used to indicate the limits between various pollution levels for various mathematical approaches, and various weights were taken into account in the pollution contribution factor. Methods were made possible by including the membership level and the weight of several mathematical models in the evaluation of environmental quality.

Keywords*: environmental quality, heavy metal, single-factor approach, pollution levels*

1. INTRODUCTION

Soil is one of the most critical and essential resources for human survival and development. The presence of high concentrations of heavy metals in Indian soil has been an issue for some time. One of the metallurgical industries' emissions is the production of toxic heavy metals during iron ore mining. Human health and environmental safety are at risk due to the presence of potentially harmful compounds in soil building. Pollutants and heavy metals are found in the soil (Baveye, P. C., 2015).

Human activities on soil and the environmental effects of heavy metal contaminated soil must be examined in order to achieve resource-constrained sustainable soil development. The environmental quality of the ground was assessed using the Pollution Index. Soil contamination levels can be determined and quantified using a variety of techniques. When it comes to environmental risks, every soil pollutant's unique traits and incoherence create uncertainty or fluidity (Baveye, P. C., 2015). The usage of sharp borders in classification systems is difficult to justify. Accordingly, environmental experts have come up with advanced evaluation systems based on questionable logic. Fuzzy techniques, by default, analyze the contribution of many contaminants comprehensively and limit the fluidity of the functions of the members. [page needed here] The influence of supervisory mistakes on evaluation findings was thoroughly investigated as part of the flying frontier problem (Al Maliki, A., 2014). Heavy metals and soils, fertilizers and animal fillers, waste water sludges, pesticides, waste water irrigation, and air deposition may be harmed by emitted material from quickly increasing industries, mining apparel, heavy metal disposal, combustion waste, and air deposition.

Heavy metal soil re-establishment and proper soil protection must be measured and re-established. Statistics identifying chemical properties for environmental occurrences, particularly in our food chain, are provided by current environmental and public health protection rules at national and worldwide levels (Fu J., Zhao C., 2014). Knowledge of the source of the pollution, vital chemical compounds, and the risk of sentimental and linked health effects on these heavy metals will all be part of the events to clean up polluted heavy metal soil. Although earth characterization will provide information on heavy metal speciation and bioavailability. Risk assessment is a valuable scientific tool for managing contaminated sites and ensuring the health of humans and ecosystems (Liu G., 2014).

1.1. Research objectives

1. Determine the environmental danger of heavy metal in soils near ferroalloy mill using contamination indicators and fluent.
2. Compare the results of the evaluations to see if an evaluation method is possible.
3. Investigating the possibilities for spectral reflectance management in metal-contaminated soils.

2. RELATED WORK

Baveye, P. C., and Laba, M. (2015). In this study we have tested the ability for the phytoextraction of sunflower mutants and at the same time analyzed the changes in spectral sheet metallophytoxic and natural metallic soils. We have also evaluated changes in the use in winter weeds and perennial ryegrass in two soils of NP fertile soil and wetting treatment combo. Sunflower-focused metals indicate metals that have been reduced to their roots and increased in the metal-focused plants. Since As-spiked soil leaves at 900 mg kg–1 level, it has been found that this vast amount is spiked in either the sunflower or a single leaf (S1-As2) or metal-mechanical blending (S1-Mix). However, due to their loamy soil design with high organic carbon and humus levels, these impacts have been mitigated greatly in polluted soils with natural metal. Cd-phyto-extract was identified at the most in the S3-flutplain contaminated land in the three soil substrates tested (S1-mix S2 and S3), however the S1-soil was contaminated with the largest pb and exhaust. The results show that the sunflower mutant is a feasible candidate for metal cleanup. Al Maliki, A., et al. (2014). According to environmental studies and risk assessments, heavy metals are contaminating the soils near the Yinshan Mine in substantial amounts. Furthermore, microbial activity in the surrounding soil is affected by heavy metal exposure. Mining rules must be tightened in order to safeguard the general public from dangerous amounts of heavy metals, as this study quantifies the need for them. Ali, H., et al. (2013). Heavy metals are one of the most persistent pollutants in water systems because of their susceptibility to degradation. The quantitative and characteristics of the high-metal contaminant in river Karasu have been monitored by four assessment approaches. These methodologies were used in the assessment of several heavy metal materials, including copper (Cu), cadmium (Cd), iron and other materials, zinc (Zn), manganese (Mn), plaster (Pb) (Fe). There were 5 (A-E) sample stations in the river (12 month, a total of 180 observations). The criteria utilized were categories with clearly identified I-IV. All water samples taken at every station with an index technique single were examined in Class IV. Samples A, B, C and D were shown as Class IV, although Class III samples of Class III indicators were reported. The aquarelle, features IV, IV, II and II have been estimated based on the mathematical procedures of the fluid sample A, B, C, D and E. The incorporation of mathematical fading element membership and weight makes water quality assessment approaches more sensitive. These same mathematical procedures could therefore be beneficial for assessing and classifying the impacts of water pollution. Alloway, B. J. (2013). Pollution of heavy metals in the soil has become an important problem. In a developing country like Bangladesh, there is a dearth of technological progress. The soil on the banks of the Buriganga River is clearly contaminated with Cr in this research at the nearby tannery. This is because tanning and sludge are every day exposed in a substantial quantity of untreated tanning to the adjacent Hazaribagh tanning plant. In the soil of this site a lot of Pb, Cd and Zn were also found. The soil and the body's intake in veggies and other items in this field are deposited and gathered in heavy metals. Cr, Pb and Cd have various harmful effects on human and animal health because of their exceedingly toxic and carcinogenic nature. The relevant authorities should take fast measures in this regard in order to prevent heavy metal contamination.

3. DATA SAMPLING AND ANALYSIS

3.1. SOIL SAMPLING

There are three basic types of soil sampling: random, systematic, and stratified. The simplest of the three methods is random sampling, which includes both random and stochastic independent sampling from potential study locations. In a pilot study, it can be utilized as a quick sampling programme. However, soil samples do not accurately represent the entire research area. To find out if the concentration of heavy metal soil in generally homogeneous areas exceeds background or regulatory constraints, this technique is frequently utilized. A detailed and precise description of the soil area and vertical distribution of heavy metals is necessary for layered and systematic sampling in a somewhat diverse location (Baveye, P. C., 2015).

Yang J., (2014) Assume that a stratified sampling technique divides a population into a number of subgroups, with each segment receiving only one sample at random. This technique allows for in-depth investigation of individual subgroups, as well as more exact and reliable estimations throughout the population. Examples of solid sample grids used in the Scholz include a bottle rack grid, which is used to collect soil samples at regular intervals, as well as a rectangular and square grid (Afzal, M., 2014). Geochemical mapping of heavy metals is used for systematic sampling because it provides a wide range of heavy metals over huge areas. Composite soil samples should also be used, as should sampling density, sample depth, and other factors. The more soil samples collected, the more representative the population of the sample will be of the ideal location conditions. Instead, sample density is usually determined by balancing the representativeness of a site's features against its ability to provide sufficient resources (Alloway, B. J. 2013).

The sample depth is determined by the study's purpose and/or the criteria of the relevant regulatory guidelines. Soil or subsurface soil sample may be required if heavy metal contamination of subterranean soils or soil pollution is suspected. Two popular approaches are soil and horizon metric sampling and sampling. The metrical sampling approach is commonly used to test suspected polluted soil (Alloway, B. J. 2013). A sampling approach to horizons is supported by more thorough environmental research. The use of a high number of sample units improves the precision of composite soil samples. A composite soil sample is made up of the same amounts of distinct subsamples. The premise is that an analysis of each composite unit can be performed by averaging a mean assessment of the composite spectrum study. Finally, it is critical to maximize the representativeness of the test field while using the fewest soils and resources possible while completing study requirements (S., Ahmad, 2013).

In a pilot study with low sample density, surface soil samples might be collected individually or in groups. Soil profiles can be obtained if polluted soils beneath the surface are suspected. The results of this preliminary analysis can be utilized to confirm the presence of contamination in the first place (Al Maliki, A., 2014). During the next stage of the investigation, if evidence of contamination is detected, a broad, systematic, and focused sampling programme may be implemented It is common practice to match the study's target region to the objectives and characteristics of the sample being used (Ali, H., Khan, 2013).

3.2. Site overviews

This research focuses on pollution in the industrial metropolis of India Plain that is used mostly to produce and operate sodium dichromate and chromic anhydride. After over 20 years of production and a broad spectrum of manufacturing facilities, the company, encompassing over 33,000 m2 of land, and over 16,000 m2 of usable space, was shut down completely in 2008. Relevant study demonstrates that a considerable amount of "the three waste" from such operations is emitted to the environment and so pollutes environmental media such as soil and subterranean water leading to the typical heavy metal sites.

3.3. Analysis of data sampling

A technique of expert assessment, based on research and an analysis of the previous history of production, of the raw materials, of the products, the production process, pollution control and site renovation measures, is used to establish the best probability and high representationality of samples (Al Maliki, A., 2014). In eight samples, the site is divided into centers with different areas and structural corrections and hydrogeological modifications are carried out. Eight samples of the soil, 0-20 cm deep. The soil was subsequently eradicated and taken into a 250-ml bottle closely associated with a bottle cap and a PDFE screening gasket. The sample was then screened into a PTFE film. The plant root system, organic residues and visible incursion body are removed after natural weaning during the shady and cold air conditions and browned in the mortar to filter samples using 10-60 or 100 mash nylon screens. Finally, the analysis at this site likely includes six common heavy metal contaminants (As, Ni, Cr, Cu, Cd and Zn). ICP-MS was used to determine the quantities Zn, Ni, Cr, Cu and Cd. And like the induced plasma spectrometer. For statistical analysis of data gathered throughout the research, Excel software (Microsoft Co.) was employed (Chen, H., 2014).

3.4. Analyses of soils contaminated with heavy metals

Appointees should be performed with adequate analytical parameters and suitable analysis procedures to produce accurate analysis results and to meet ultimate objectives of the contaminated soil heavy metal study (Chen, H., 2014). Soil is frequently evaluated as total Heavy Metal concentrations for regulatory purposes since in the primary regulating routes; absolute heavy metal levels in the Canadian Environmental Quality Guidelines are reviewed. Chemical speciation for heavy metals has an ever more crucial effect on the fate and toxicity of contaminants. The probable health and ecological ramifications of heavy metals are typically desirable in locations with chemical speciation (Fu J., Zhao C., 2014). In addition, anthropogenic inputs were discovered and probable polluted sources were found among the sources using an isotopic test of heavy metals, in particular Pb.

4. PROPOSED METHODOLOGY

4.1. Pollution index techniques calculation formulas

The environment of eight polluted soils was assessed using two different pollution index approaches (single factor index method and complete Nemerow Index method). The following is the formula for calculating the one-factor index:

The single-factor index technique can be calculated as:

$$\mathrm{Pi} = \frac{\mathrm{Ci}}{\mathrm{Si}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (4.1)$$

The Nemerow integrated index method's mathematical formula is:

$$\mathrm{P} = \sqrt{(1/n \sum_{i=1}^{n} Pi)^{\wedge}2 + \frac{(Max(Pi))^{\wedge}2}{2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.2)$$

Where Pi is the heavy metals pollution index, CI refers to the genuine heavy metal monitoring data I (mg•kg-1). If the environmental quality criterion is reached, the data are obtained from the grade a standards set out in Provisional Soil Environmental Index (HJ350-2007).

5. RESULT AND DISCUSSION

5.1. Comparison of the two pollution index methods

For the eight soils, the results were established for Class III, II, II, III, V, V, V and II according to the maximum membership grading criteria. As shown in Table II. Nonetheless, in classes II, I, I, II, V, V, V and I the comprehensive indexing technique has detected the environmental quality of eight soil areas. In addition to considering the maximum pollution index, the averaging pollution index is also included in Nemerow Comprehensive Index P.

The preceding findings imply that soil quality is worse than the single factor index approach's complete index model. The disparities in value were due to the two systems' different evaluation principles (Fu J., Zhao C., 2014). Other elements were eliminated from the single factor index technique, which only covered the most critical aspects. High (much polluted) concentration factors are likely to have fatal consequences in the one factor technique's final assessment conclusions. Increased environmental quality, on the other hand, was regarded as the most important criterion and average contribution for both the extensive indexing methodology used in previous study and the evaluation results. An example of employing Table.1 models can demonstrate the above-mentioned differences in the two approaches of the pollution index. As a result, as compared to the single factor index method, the full index methodology is more sensible.

5.2. Comparison of two fuzzy mathematical methods

Table.1 summarizes the results of the environmental assessment of heavy metal pollution based on two different methodologies. The weighted decision quality in the average model is higher than the decision quality in the individual components because of the differing levels of pollutant class membership. The evaluation outcomes differed depending on the various evaluation goals and ideas. In reality, the single components that determine a model are only the most important aspect (Liu G., 2014).

The impact on the outcomes of the evaluation therefore largely reflects greater relative contents and severe pollution in the case study. The assessment findings are derived by individual competitors' indexes, while weighted average models take the importance of each component fully into consideration and distribute the contribution by weight. As in S4, due to the interference of a substantial relative Cr concentration, the assessment of the single-factor model decision is III, but I pick the weighted average model (Al Maliki, A., 2014).

Table.1. Fuzzy mathematical membership levels at five levels for eight contaminated soils

S.No.	Level of soil	Single factor deciding model							
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
1.	I	0.262	0.890	0.845	0.370	0.050	0.013	0.012	0.890
2.	II	0.450	0.112	0.163	0.192	0.015	0.000	0.000	0.110
3.	III	0.295	0.001	0.000	0.445	0.000	0.000	0.000	0.000
4.	IV	0.000	0.000	0.000	0.000	0.000	0.002	0..000	0.000
5.	V	0.000	0.000	0.000	0.000	0.940	0.991	0.990	0.000
	Environmental quality	II	I	I	III	V	V	V	I

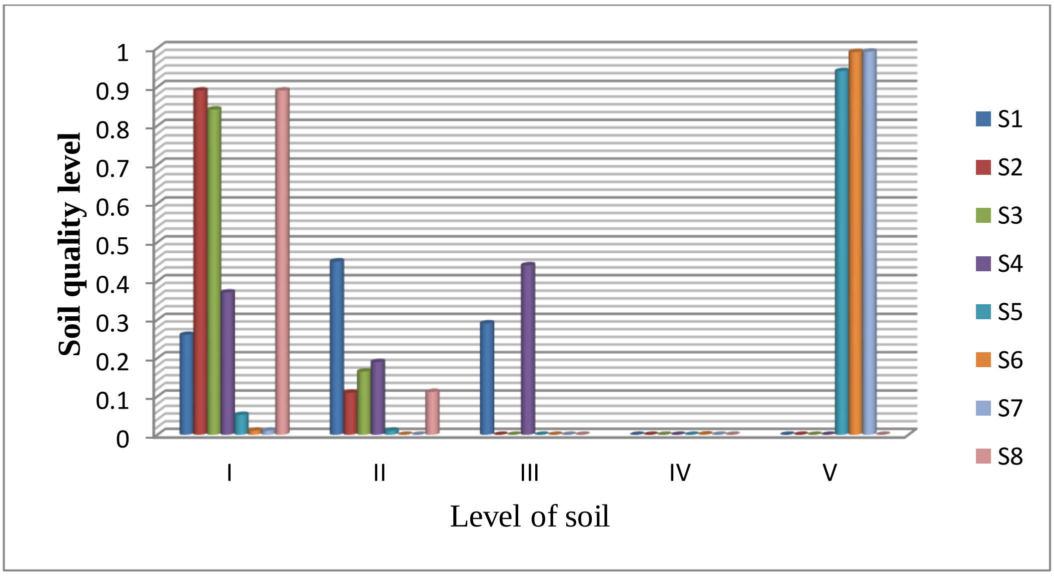

Figure.1. Single factor deciding model

Table.2. weighted average model

S.No.	Level of soil	Weighted average soil model							
		S1	S2	S3	S4	S5	S6	S7	S8
1.	I	0.540	0.969	0.920	0.590	0.120	0.045	0.011	0.962
2.	II	0.281	0.033	0.085	0.125	0.011	0.000	0.000	0.040
3.	III	0.180	0.000	0.000	0.285	0.000	0.000	0.000	0.000
4.	IV	0.000	0.000	0.000	0.000	0.000	0.000	0..000	0.000
5.	V	0.000	0.000	0.000	0.000	0.875	0.960	0.991	0.000
	Environmental quality	I	I	I	I	V	V	V	I

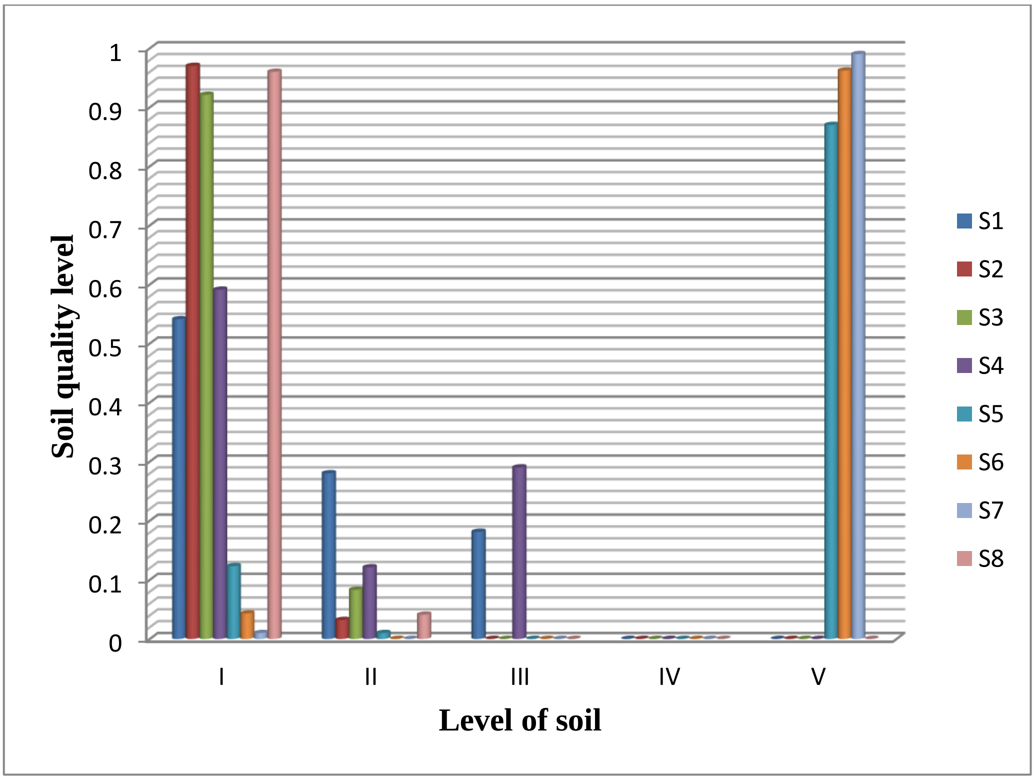

Figure.2. Weighted average soil model

The weighted average model had slightly better environmental properties than the one-factor strategy, such as the link between the two contamination index methodologies. The application provides yet another demonstration of the two difficult mathematical techniques (Table.1. and 2). The outcomes varied depending on the evaluation aims and principle. The outcomes are not the same. The dominant element became more visible and its impact was lessened under a factor paradigm. Every component, on the other hand, was suitably assessed as a contributing factor to the weighted average model, and its weights were primarily influenced by its total effect on the weighted average model of all components (Fu J., Zhao C., 2014).

6. CONCLUSIONS

A pollution index and liquid mathematical approaches on environmental parameters have been used to study 8 heavy-metal soils (S1-S8). The complete index model for soil S1-S8 has been examined for Classes III, II, II, III, V, V, V and II. The overall index model was the dominant parameter and the average contribution for integral environmental quality for all factors II, I, I, II, V, V, V and I compared to a single factor index technique. The two methods of fluid mathematics (average single-factor modeling and model weighted) had identified the environmental features of the single factor method for categories II, I, I, III, V, V, V and I respectively and the weighted average model for categories I, I, I, V, V, V, and I. The assessment aims and principles of the two fluid techniques differed. The pollution index technique incorporates multiple degrees of environmental quality with distinct borders; however finding the stringent limitations of the criterion with the frantic mathematical approach is difficult. Member functions were utilized to define the limit between distinct pollution levels and to offer varied weights in the fuzzy mathematical method with the pollution contribution of each element. Each factor's membership and weight were incorporated into environmental risk assessment models; the mathematical model was shifted in comparison to present processes.

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