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A Conceptual Framework for Classification Management of Contaminated Sites in Guangzhou, China

Xiaonuo Li [1,2], Rongbo Xiao [3,*], Weiping Chen [1,*], Chunying Chang [3], Yirong Deng [3] and Tian Xie [1,2]

1 State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China; lixiaonuo1988@163.com (X.L.); sky_nick_2008@hotmail.com (T.X.)
2 University of Chinese Academy of Sciences, Beijing 100049, China
3 Key Laboratory of Contaminated Sites Management and Remediation of Guangdong Province, Guangdong Provincial Academy of Environmental Science, Guangdong 510045, China; changcy24@163.com (C.C.); ecoyrdeng@163.com (Y.D.)
* Correspondence: ecoxiaorb@163.com (R.X.); wpchen@rcees.ac.cn (W.C.); Tel.: +86-020-83543127 (R.X.); +86-010-62843981 (W.C.)

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Abstract: Contaminated sites have become a worldwide issue because of significant environmental and health risks to users of the land. With the aim of synthesizing useful services delivered by land reuse for environmental, social and economic benefits, effective management measures have been taken nationally and regionally to rehabilitate contaminated sites. The unacceptable risks, large number of contaminated sites and urgent demand for land supply make it necessary to centralize limited resources within contaminated sites. In reference to the classification rationale in developed countries trying to deal with contaminated sites in an integrated, saving and timely manner, we design a conceptual framework that considers the unique context in China. We classify contaminated sites in five steps, namely: listing, investigating, filing, classifying and managing. Based on the classification results, effective suggestions are proposed for graded and classified management and further decision-making at the highest level of design. The results show that potential contaminated sites can be divided into high, medium and low priority based on four factors (social concern, redevelopment demand, health risk and ecological risk). Site-specific management strategies focusing on environmental monitoring, detailed site survey and immediate remediation, respectively, are suggested that focus on corresponding contaminated sites in different priorities. The feasibility and reliability of the proposed framework are further discussed in the final section.

Keywords: classification framework; contaminated site management; prior remediation; Expert Scoring Method; Analytic Hierarchy Process

1. Introduction

Contaminated land has attracted worldwide concern because of its significant adverse effects on human health, ecological function, the environment and land reuse [1,2]. Many countries have considered contaminated site issues in national environmental management systems through a variety of soil protection policies [3–5], such as the *Comprehensive Environmental Response Compensation and Liabilities Act (CERCLA)* commonly referred to as *Superfund* in the US [6], the *Town and Country Planning Act* in the UK [7] and the *Recommended Canadian Soil Quality Guidelines* in Canada [8].

One of the key steps in contaminated site management is classification based on multiple factors including risk level, since there are a large number of potential contaminated sites while financial and personnel resources are often limited. According to the existing hazards or potential threats to human health or environment, contaminated site classification categorizes potential contaminated sites into different risk levels in order to implement corresponding management measures. The prioritization of contaminated site management is significantly important for decision makers, especially at the initial design stage. Since the 1980s, developed countries have made more effort to establish a classification system supported by feasible evaluation factors, classification methods, technical guidelines, and database management systems of contaminated sites. The Hazard Ranking System (HRS) in the US [9], the National Classification System for Contaminated Sites (NCSCS) in Canada [10] and the Contaminated Land Management (CLM) in France [11] are all widely acceptable tools to prioritize contaminated site management and accelerate remediating contaminated sites with high risks. As a result, the HRS system has contributed to list more than 1770 sites on the National Priority List (NPL), among which, 387 sites have been cleaned up by 2014 [12]. However, the ranking ability of the classification system still needs to be highly improved due to the uncertainty due to field sampling, model parameters and evaluation methods [13–20].

With the upgrade of industrial structures and adjustment of urban layouts in China, the relocation of old and seriously polluting industries from urban centers has left behind a huge number of seriously contaminated sites [21,22]. Hundreds of policies, therefore, have been formulated to achieve the ambition of a "zero contaminated site" in parallel with a range of remediation programs that have been or are being implemented in China [23]. For instance, the *Technical Guidelines for Environmental Site Monitoring (HJ 25.2-2014)* and *Technical Guidelines for Site Soil Remediation (HJ 25.4-2014)* were nationally issued recently. Four local standards, including *Environmental Site Assessment Guideline (DB11/T656-2010)*, *Technical Guideline for Contaminated Sites Remediation Validation (DB11/T783-2011)*, *Technical Guideline on Construction and Operation of Heavy Contaminated Soil Landfill (DB11/T810-2011)* and *Screening Levels for Soil Environmental Risk Assessment of Sites (DB11/T811-2011)* are released in Beijing based on the specific social-economic-environmental context. Particularly, the State Council recently released the *Soil Pollution Prevention Action Plan* to further push the implementation of soil pollution prevention and control. However, China is still at the initial stage of contaminated site management, which leads to ineffectiveness in policy development and implementation including lack of a comprehensive classification system for contaminated sites. To our knowledge, much literature has appeared in scientific journals dealing with contaminated sites and finding mechanisms for accelerating the clean-up process. However, only limited studies on contaminated site classification systems have been carried out in China with respect to lessons from the developed countries [24,25] and general classification design rather than specific consideration [26–29]. These studies tended to evaluate mainly by risk assessment results, which were undoubtedly reliable and had valuable references for contaminated site classification. However, incomplete information on contaminated sites in China, time consuming and huge sampling costs, and lack of technical methodology and accumulated experience all inhibit the feasibility of risk-based classification at initial design.

To address the problems mentioned above, a conceptual framework of classification management is preliminarily depicted in this study to manage contaminated sites efficiently. However, the classification framework proposed in this research does not aim to justify how it improves previously developed and widely accepted existing methodologies. Instead, in a region-specific context, it refers to the classification rationale in developed countries trying to deal with contaminated sites in an integrated, cost-saving and timely manner. This is especially important considering the political sensitivity, huge market capacity, large-scale industrial relocation and early management stage of contaminated sites in Guangzhou China, which is one of the oldest industrial cities in China facing serious challenges in contaminated site management. Four factors, including social concern, redevelopment requirement, health risk and ecological risk are considered as the classification basis, scored by the Expert Scoring Method (ESM) and weighed by the Analytic Hierarchy Process (AHP) to classify the contaminated sites quantitatively. As a result, contaminated sites are grouped into three types and treated with various specific measures. Moreover, the strategic significance as well as the uncertainty of the classification framework is discussed.

2. Materials and Methods

2.1. Case City: Guangzhou

Land resource plays a significant supporting role in rapid economic and social development. However, soil resources in China have faced unwarranted abuses, different levels of pollution and unrelenting development pressures for a long time. Meanwhile, little attention has been paid to soil pollution in terms of its characteristics of latency, accumulation, lag and non-intuitive. In recent years, shut-down and relocated industrial enterprises, which have greatly intensified in many cities in China (e.g., Beijing, Chongqing and Guangzhou), have resulted in a large number of potential contaminated sites that should be investigated, evaluated, remediated and supervised. In Guangzhou, a total of 303 industrial companies planned to relocate by 2015, including some that may greatly threaten the environment (206) and involve hazardous chemicals (92) (Figure 1). This is the result of the so-called "three old" reform (old towns, old factories and old villages), which is supported by *Opinions on Implementing "Three Old" Reform to Promote Saving and Intensive Land Use (Guangdong Government Circular 78 [2009])* for the purpose of revitalizing the construction land and facilitating intensive land redevelopment. The Land Development Center of Guangzhou is responsible for spare sites that planned for reuse as residential land, commercial land or other land types in future urban planning.

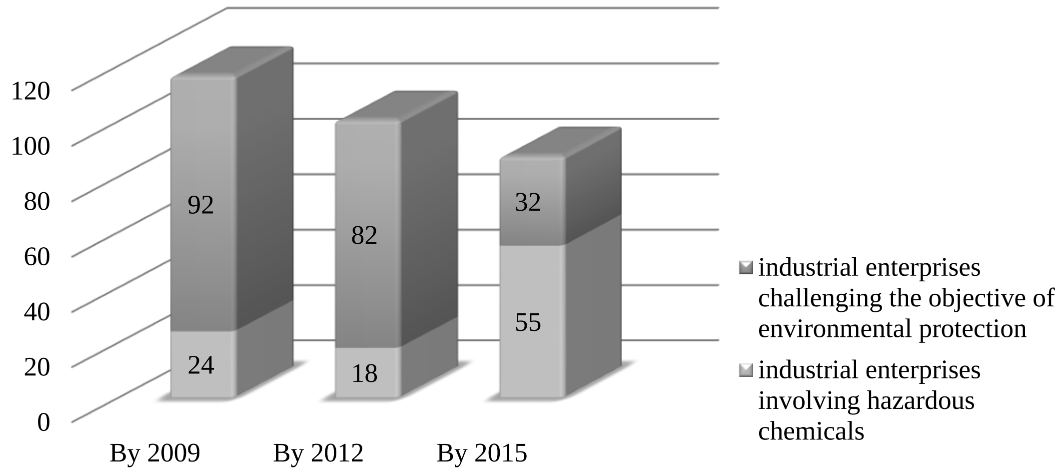

Figure 1. Relocation of companies in "retreat into three" project in Guangzhou.

To relieve the glaring contradiction between idle land and rapid land development, the redevelopment of land left behind by an enterprise's relocation requires a new urban land use strategy as a part of urban planning and land management. Compared with leading cities in policy making and practical implementation (e.g., Beijing, Shanghai and Chongqing), Guangzhou falls relatively far behind in treating environmental issues associated with contaminated site management. The government recently realized the importance of regulating industry relocation and managing contaminated sites. As a result, a series of policies including (1) *Opinions on Promoting "Retreat Into Three" Project of Enterprises (Guangzhou Government Circular 8 [2008])* focusing on the optimization of urban industrial structure and spatial layout; (2) *Opinions on Implementing "Three Old" Reform to Promote Saving and Intensive Land Use (Guangdong Government Circular 78 [2009])* and *Opinions on Saving and Intensive Land Use (Guangzhou Government Circular 12 [2014])* focusing on promoting the change of land use types; *and* (3) *Program on Soil Environment Protection and Comprehensive Cleanup (Guangdong Government Circular 51 [2014])* focusing on soil environment protection and comprehensive cleanup, are issued to regulate environmental management in the process of land transfer from an enterprise's relocation to land reuse. Responding to the policy requirements to ensure the safe reuse of the remaining sites, the general status of the sites had been surveyed to examine the existing or potential risks to environment and human health. Thirteen sites, including 3 located in Liwan District, 9 in Tianhe District and 1 in Haizhu District in Guangzhou, were surveyed in May 2015 to understand the site features of characteristic pollutants, pollution areas, site status and sensitive surroundings. As a result, the general information of potential contaminated sites was organised and identified by relevant stakeholders including experts from the Guangdong Provincial Academy of Environmental Science and governmental departments such as environmental protection departments (Table 1).

As a result of industrial relocation, contaminated sites in Guangzhou are generally facing harsh challenges: (1) There is a large number of plants and they have complicated pollution sources. The overall data of the legacy of polluted industrial sites in Guangzhou is not yet available but it has been estimated in a wide and scattered distribution that creates obstacles for site remediation and regulation. The involved industrial types include: chemical, printing and dyeing, textile, iron and steel, machinery, rubber, electroplating, papermaking and clothing, etc. (2) Serious pollution and high risks. In Guangzhou, pollution caused by heavy metals is the most prominent. Of these, Cd constitutes the highest threat, followed by Zn, Cu, Hg, As, Ni and Pb. Some industries adjacent to environmentally sensitive areas pose high risks to the ecological environment and human health. (3) Indeterminate liability and weak management. Though the basic principle of "polluter pays" is germane, liability for soil pollution and paying for contaminated site remediation often become disputed issues. A long history of operation, changeable ownership of sites and missing information on production processes may all lead to untraceable responsibility. Besides, the regulatory framework and site management responsibilities of environmental protection departments remain relatively underdeveloped in China, which causes significant difficulty in effective supervision and management. (4) The pressing redevelopment and secondary pollution concerns. Both rapid urban development and high population density of Guangzhou call for continued growth in land supply. Therefore, the sites left behind by an industrial enterprise's relocation are urgently needed for reuse as residential land, commercial land or other land reuse types. However, the secondary pollution caused by remediation chemicals and improper operation during land conversion triggers the attention of the media and the public. In this case, higher requirements for management ability of administrative departments are needed.

Table 1. General information of 13 potential contaminated sites.

Site	Industrial Type	Pollutant	Contaminated Area	Site Status	Surroundings
1	Food Manufacture	-	-	Creative garden for recreation, most plants remained or are transformed into restaurants and exhibition spaces.	Residential areas, Pearl River
2	Agro-food Processing	-	-	Most plants remained, or are rented to transportation and decoration material companies.	Water plant
3	Food Manufacture	-	-	Most plants remained and some are in operation.	Residential areas
4	Transport, Storage and Postal Service	-	-	Construction land	-
5	Food Manufacture	-	Unidentified	Most plants are idle, or rented to advertising and decoration companies.	Hospital, residential areas
6	Wholesale and Retail	Incomplete information, unidentified			Residential areas, school
7	Water Production and Supply	Halogenated hydrocarbons	Unidentified	Idle	-
8	Road Transport	Diesel, heavy metals (Pb)	Unidentified	Car rental company	Water plant
9	Textile	Kerosene, acid, alkali	Unidentified	Subway station	Residential areas
10	Metal Products	Organic compounds (diesel, benzene), heavy metals (Pb, Zn)	Product workshop, diesel repository, oil leakage area	Parking	-
11	Printing	Organic compounds (benzene, phenolic resins), heavy metals (Cd, Cr, Pb)	Unidentified	Creative garden, most plants remained or were rebuilt.	Residential areas, hospital
12	Rubber Products	Organic compounds (petroleum hydrocarbons, aniline), heavy metals (Pb, Zn)	Unidentified	Most plants are dismantled for recreational purposes.	-
13	Metal Products	Organic compounds (petroleum hydrocarbons, benzene), heavy metals (Pb, Zn)	Product workshop, boiler room	Driving school, parking	Pearl River

2.2. Classification Framework

Although significant efforts have been made both nationally and regionally to standardize site management procedures and facilitate remediation work in China, there is not yet a collectively recognized priority list representing a cohesive national plan for contaminated site classification. However, in some policies, clauses are generally defined as "soil remediation preferentially focus on spots that (1) are in proximity of residential areas, arable lands, drinking water and groundwater supplies, (2) present high human health and/or ecological risks, and (3) are in pressing redevelopment". In Guangzhou, the features of contaminated sites such as a large number of sites, serious pollution, scattered distribution and demand for quick redevelopment, inevitably call for a feasible classification method that can be easily applied, widely accepted and properly explained. A classification framework that conforms to relative national standards, therefore, is conceived in the specific context of Guangzhou to guide the selection of contaminated sites, and the allocation of cost-effective resources for further contaminated site management in an orderly manner (Figure 2).

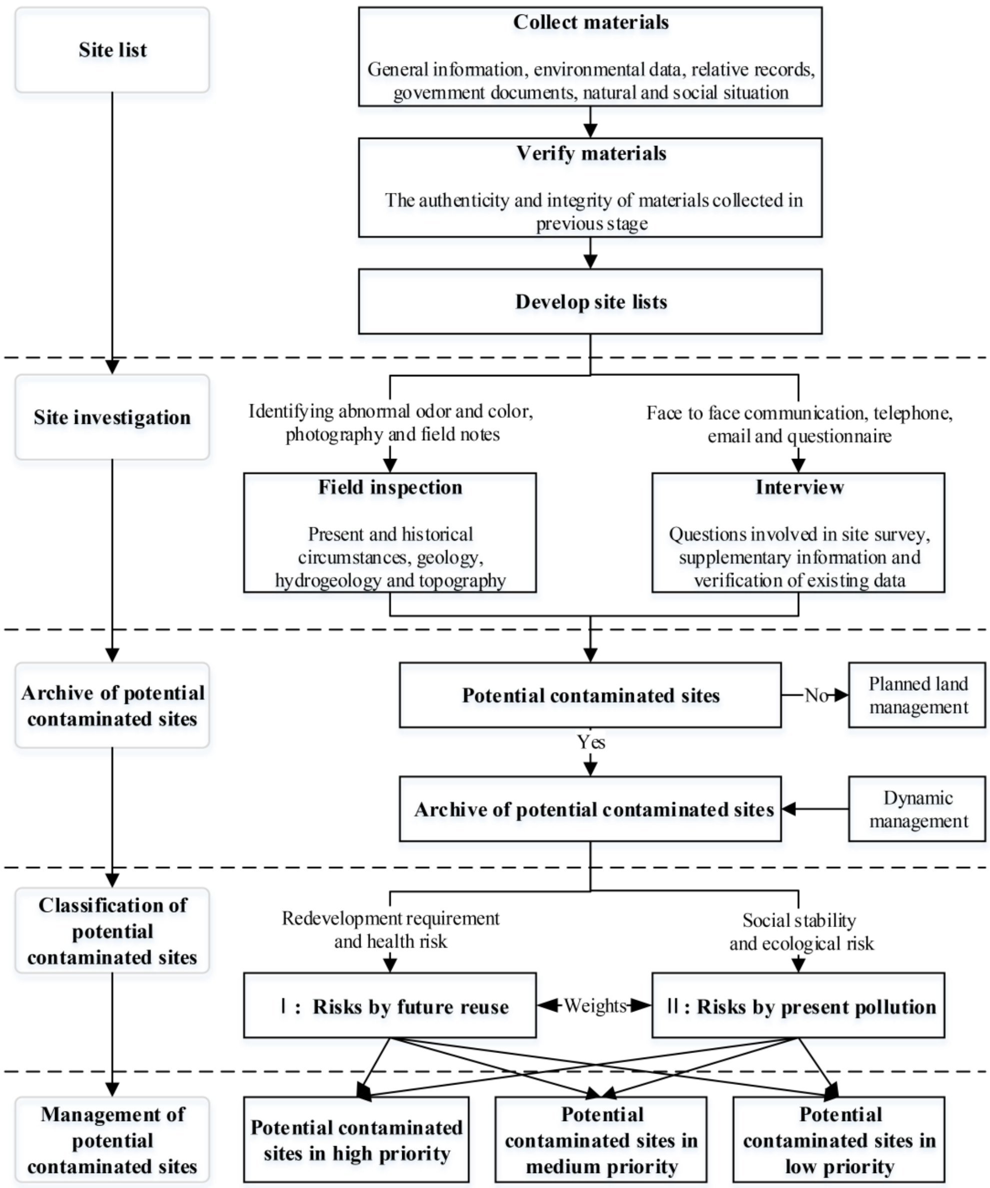

Figure 2. The classification framework for contaminated site management in Guangzhou.

1. Develop a site list: As shown in Figure 2, the fundamental requirement for a site list is to collect relevant information. The general information provides the official site name, location, geographic coordinates, owner/operator, years of operation, industrial type and current status (e.g., operational, bankrupt, equipment removed or plants dismantled). The environmental data records soil and groundwater pollution, mass, volume and areal size of sources or volume of spills, waste treatment, storage and disposal activities that occurred both in the past and at present, important resources and environments on or near the site. The site-related records include imported raw material and production lists, facility layout, process flow diagram, underground pipeline map, environmental monitoring data and environmental impact report, etc. The government documents are files released by governmental departments, for instance, the regional environmental protection plan and environmental quality bulletin, which are released by environmental protection department. The natural and social situation describes the topography, soil, hydrology, geology, meteorology, and population density, distribution, sensitive objects, land use, development plan, national and local policies, respectively. As a result of organizing the information mentioned above, a list for each site is developed by verifying its authenticity and integrity.
2. Investigate the context of sites: Follow the environmental investigation procedure in *Technical Guidelines for Environmental Site Investigation (HJ 25.1-2014)*, and, based on the information collected in the first step, the general information (including official site name, location, area, industrial type, building, facility, production activities, land use, operator, historical and current pollution (type, mass, volume, extent and range), and sensitive environments on or near sites) should be examined in step 2. To realize this, approaches such as a field survey and interviews are applied, particularly focusing on emission sources and migration paths that have caused or can potentially cause soil or water pollution and result in unacceptable risks. On the one hand, sources can be distinguished through visual and olfactory inspection during site reconnaissance. Aerial photography and records are also useful references to identify current indiscernible sources due to historical changes. On the other hand, by means of face-to-face communication, telephone, email and questionnaire, interviews with key stakeholders such as facility representatives, employees and surrounding residents are extremely helpful to supplement and identify reliable site information. This is a basic step to understand any site, and can provide valuable information for further information management and site classification.
3. Establish and manage the archive of potential contaminated sites: At the end of the preliminary investigation, potential contaminated sites with sufficient details covering all pertinent features are identified and recorded. Moreover, the basic context of the site, including its geology, hydrology, hydrogeology, contamination history, point sources, expected contaminants and contaminant levels, spreading pathways and potential receptors, exposure pathways, etc., can be understood in a conceptual site model (CSM). As long as new information is available, the model should be updated either by sampling or regularly monitoring local environmental protection departments within their jurisdiction.
4. Classify potential contaminated sites: Based on the investigation results from step 1 to 3 and the site reuse plan, the contaminated sites will be divided into two types considering four factors, namely: site reuse urgency, human health risks, ecological risks and social public attention. The first type focuses on human health risks generated by site remediation and reuse, while the second type is concerned with ecological risks caused by current soil contamination. The methods to weight and score the concerned factors will be specifically explained in the following section.
5. Manage potential contaminated sites specifically and respectively: The total score of each site can be calculated following steps 1 to 4, and three levels of contaminated sites will be ranked in high, medium and low priority. Specific actions, including environmental monitoring, further site investigation, site remediation and restricted land reuse, are taken for sites of different ranks. Additionally, suggestions are proposed for sites with different features, specially, for sites

in urgent redevelopment, remediating immediately; for sites in high health risks, controlling migration and diffusion of pollutants and preventing human exposure; for sites with high environmental risks, investigating the environment and assessing risks for fragile receptors; and for sites that attract high social attention, communicating with the public in a positive, official and responsible way.

2.3. Classification Factors and Scoring Method

Four factors, including site reuse urgency, human health risks, ecological risks and social public concern are identified for classification and expressed by secondary indexes, based on (1) the features of a contaminated site, as well the social and economic context of Guangzhou described in section 2; and (2) "round table" discussion depending on theoretical professional and practical experience of local stakeholders, including the researcher, policy maker and practitioner. As a result, the classification factors, level, value and scoring method are widely agreed as shown in Table 2:

- Site reuse urgency: according to land value, the type of land use, regional development plan and surrounding property value, four scales are defined in terms of redevelopment time as: 0–2 years, 2–5 years, 5–10 years and >10 years. The more pressing the need for reuse, the larger weight to value, and the higher the management priority.
- Human health risks: human health risk is the likelihood that soil pollution may have damaged or will damage the health of individuals who are exposed to contaminated soil, now or in the future. It is the most concerning aspect among the four factors and the main purpose of site management. Three indicators include: cumulate excess multiples (1–10, 10–100, 10–1000 and >1000), exposure pathways (oral intake of soil, skin contact with soil, inhalation of soil particles, intake of gaseous pollutants from soil or groundwater) and ratio of population density in the region affected by characteristic contaminations (<0.1, 0.1–1, 1–10 and >10 times compared with average population density of Guangzhou). They are assigned with different values to quantify potential risks to human health. Contaminated sites with higher cumulate excess multiples, more exposure pathways and greater ratio of population density should be given top priority.
- Ecological risks: contaminated sites which pose potential risks to water conservation areas and water recharge areas, areas located in or nearby areas providing rich surface water and water exchange, areas that contain special protection areas such as cultural relics and historical sites requiring special attention, are quantified by experts on a scale from 0 to 20. The more sensitive the object, the higher the score.
- Social public attention: the contaminated sites, which primarily concern the media, public or other social parties, are suggested to be given prior management. Scores increasing from 0 to 20 indicate the degree of concern varying from low to high.

To understand the overall performance of each site, the Expert Scoring Method (ESM) and the Analytic Hierarchy Process (AHP) are applied to synthesize the scores of eight indicators. Three types of contaminated sites were ranked in high ($S \geq 20$), medium ($12 \leq S < 20$) and low ($S < 12$) priority. ESM is a quantitative process in which a number of representative experts in a specific research field are consulted to estimate their perception on evaluation factors, especially when factors are difficult to quantify by technical methods [30]. AHP values different factors with different weights and integrates the mean of all factors, which is the perception of experts to make pair-wise comparison to judge the relative importance between different factors [31]. The total score of each site constitutes an accumulation of eight factors, of which the single score of each factor is the multiplication result of the corresponding value and weight. The combination of these two methods can not only quantify and centralize the factors in different dimensions but also make sites with different features comparable, which constitutes the indispensable premise of priority ranking.

Table 2. Scoring matrix of potential contaminated site classification.

Type	**I: Risks by Future reuse**																**II: Risks by Present Pollution**			
Factor	Site reuse urgency (Year)				Cumulate excess multiple of characteristic contamination [1]				Human health risks								Ecological risks			Social public attention
									Exposure pathways (Quantity)				Ratio of population density				Water source	Surface water	Special protection area	
Level	0–2	2–5	5–10	>10	1–10	$10–10^2$	$10^2–10^3$	$>10^3$	0–1	1–3	4	>4	$<10^{-1}$	$10^{-1}–1$	1–10	>10				
Value	20	5	2	1	1	2	5	20	1	2	5	20	1	2	5	20	0–20	0–20	0–20	0–20

[1] Cumulate excess multiple [32]: take the average value of pollutant in the environmental background value of a region as the reference value, the smaller the cumulative index the less the pollution. Formula: $\mathrm{Pl}_i = (C_i - C_B)/C_B$, in which, Pl_i is the cumulate excess multiple of pollutant *i*, C_i is the measured value of pollutant i and C_B is the background value of pollutant *i*.

However, the establishment of a classification framework for contaminated sites is a systematic project in the long-term that can only be supported by vast practices and much experience. It is possible to identify classification factors and methods that conform to specific sites. In this sense, China is still at the beginning of contaminated site management. The overall framework, the classification procedure, factors and scoring methods discussed in this paper, on the one hand, still need to be greatly improved. On the other hand, they need much theoretical, methodological and practical effort to follow up this work, and, in particular, verify it through practical application.

3. Results and Discussion

A conceptual framework for contaminated site classification was initially proposed in this research that conforms to technical guidelines on site investigation, specific regional context of society, economy and environment as well as reliable understanding of key stakeholders. This framework aims to provide a standard procedure for the quick screening of contaminated sites to be treated with effective allocation of limited resources, which can be easily used and are widely accepted, but need to be further verified in practical applications. Based on the ranking result, three types of contaminated sites are respectively grouped into low, medium and high level management priorities, and corresponding management measures are suggested aiming at specific problems:

- For sites in low management priority, long-term environmental monitoring is preferentially suggested instead of immediate soil sampling and risk assessment, specifically including: (1) develop relevant regulations to limit activities in these sites to reduce human exposure to pollutants; (2) set up monitoring spots to regularly observe the mitigation and transformation of pollutants, especially the downstream direction of groundwater around the site boundary; (3) individuals or organizations who are responsible of the sites should carry out detailed site investigation and risk assessment within 5 years, submit site investigation reports to environmental protection departments for approval and identify whether further actions should be taken and how to take them, if necessarily.
- Sites are grouped in medium management priority in cases if site pollution cannot be identified due to lack of useful environmental information. However, judged by industrial type, professional knowledge and site investigation, the potential risk is not high enough to cause a environmental or health hazard in the short-term. To deal with these sites, regulations restricting human activities and spots monitoring pollutants, preliminary sampling survey and risk assessment are recommended to identify whether further actions should be taken and how to be taken if necessarily.
- The sites neither in the low nor medium level are grouped into the high management priority. They constitute great environment and health risks, social pressure or redevelopment urgency. A remediation directory for highly-prior sites in Guangzhou should firstly be developed to guide a timely and orderly management. Further investigation, evaluation and remediation by responsible parties in a fixed time are necessary to ensure the mitigation of potential risks to sensitive objects.

Additionally, for contaminated sites that are difficult to classify for various reasons, corresponding management measures are also suggested in terms of special social concern, urgent redevelopment requirement, high human health risk and high ecological risk: (1) for contaminated sites of special social concern, confirm the truthfulness of social views, disclose the pollution situation of concerned sites and guide the public perspectives properly to avoid social instability; (2) for contaminated sites needing urgent redevelopment, carry out detailed site investigation and risk assessment to identify if remediation is mandatory; (3) for contaminated sites with high human health risk, develop relevant regulations to limit human activities in these sites to reduce human exposure to the pollutants. Meanwhile, employ economic and effective remediation technology to control or clean up the pollutants. More attention must be paid to long-term monitoring to track if the pollution risk is below an acceptable level or up to the expected remediation results; (4) for contaminated sites with high ecological risk, take sensitive objects as risk receptors to implement risk assessment, and take specific further actions according to the evaluation results.

With the dynamic development of Guangzhou, other diverse factors potentially influencing contaminated site management should also be considered to improve the reliability of the classification framework and the practicability of future implementation. Other components, including factor values, scoring method and knowledge of different evaluators, which may cause uncertainty to some extent, need to be examined in massive engineering practices of more contaminated sites with various features.

4. Conclusions

To effectively remediate and reuse the land, establishing the priorities of remedial actions has been recognized as an appropriate tool and a crucial constraint for early decision making, which has initiated the development of the classification framework for contaminated sites internationally. Although a conceptual framework is initially proposed with space for improvement, we have made important progress in priority ranking for contaminated site remediation, providing a supportive foundation for contaminated site management and meeting the requirements of urgent redevelopment, especially given that no unified and standardized classification procedure is accepted in China. The conceptual proposal and practical implementation of classification framework indicate that:

1. Considering the realistic context of contaminated sites in Guangzhou, the proposed classification framework is significantly valuable for innovatively considering four assessment factors (site reuse urgency, human health risks, ecological risks and social public concern). These are broken down into secondary indicators, and the qualitative judgment is transformed into quantitative operational scores by weighted sum method combining the Analytic Hierarchy Process (AHP) and the Expert Scoring Method (ESM);
2. With the purpose of effectively accelerating land reuse, prioritizing management procedures and allocating human, material and financial resources, the conceptual framework can categorize contaminated sites into three types according to the results of: information, field survey and interview with relative stakeholders (e.g., local experts and industrial managers). Different management strategies including timely site remediation, further soil sampling and regular pollution monitoring were specifically suggested for sites with different priorities or with different features;
3. The national classification of contaminated sites is a long-term project, in which case studies and rich practical experiences are necessary for verifying and improving evaluation factors and scoring methods. As one of the leading cities in contaminated site management in China, the features of intensive industrial development, pervasive pollution and high land demand in Guangdong make it typical and representative as a pilot case and successful example in terms of the classification process, the evaluation factors and the quantifying methods, which can all be referred to by other regions in contaminated site classification. In this sense, testing many sites in the long-term, and continuous reliable and practicable improvement of the classification framework will make this work meaningful and applicable to a larger scientific community.

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