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Research article

Analysis of influencing factors on public perception in contaminated site management: Simulation by structural equation modeling at four sites in China

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ABSTRACT

Public perception towards contaminated site management, a not readily quantifiable latent parameter, was linked through structural equation modeling in this paper to 22 measurable/observable manifest variables associated with the extent of information dissemination and public knowledge of soil pollution, attitude towards remediation policies, and participation in risk mitigation processes. Data obtained through a survey of 412 community residents at four remediation sites in China were employed in the model validation. The outcomes showed that public perception towards contaminated site management might be explained through selected measurable parameters in five categories, namely information disclosure, knowledge of soil pollution, expectations of remediation and redevelopment outcomes, public participation, and site policy, along with their interactions. Among these, information dissemination and attitude towards management policies exhibited significant influence in promoting positive public perception. Based on these examples, responsible agencies therefore should focus on public accessibility to reliable information, and encourage public inputs into policies for contaminated site management, in order to gain public confidence during remediation and regeneration projects.

1. Introduction

Contaminated sites need to be restored or managed in a sustainable manner which minimizes human health and eco-environmental risks, and (ideally) creates social, environmental and economic gains from investment (Bardos et al., 2016; Hou et al., 2014a). Risk management can be accomplished through a combination of legal mechanisms and/or setting policies, guidelines and strategies (Cundy et al., 2013; Ferguson, 1999; Jin, 2012; Johansson et al., 2011; Rodrigues et al., 2009a, 2009b; Sousa, 2001; Swartjes et al., 2012; Thornton et al., 2007), employing effective remediation technologies or site management strategies (Blanc et al., 2004; Busset et al., 2012; Cadotte et al., 2007; Cappuyns, 2013; CLARINET, 2002; Hou et al., 2014b; Smith, 2010; USEPA, 2008; Volkwein et al., 1999), and engaging with the public/local stakeholders to manage site use, limit exposure pathways and to more effectively deliver remediation or management interventions (Alberini et al., 2007; Eiser et al., 2009; Feldman and Hanahan, 1996; Grasmück and Scholz, 2005; Scholz and Siegrist, 2010; Tonin et al., 2011; Vandermoere, 2008). In relation to the latter, restoration scheme success (in terms of effective risk management, and maximization of social, environmental and economic gains) depends not only on how the responsible parties implement remediation or management plans, but also on the participation and support of local residents whose wellbeing hinges upon the final outcomes (Li and Tan, 2012). A number of international groups and projects have argued that effective engagement with local stakeholders is key in reducing remediation project risks, including failure to gain acceptance and delays due to antagonistic relationships, and also as a means of reducing project management costs and timescale (Cappuyns, 2016; Cundy et al., 2013; RESCUE, 2005; REVIT, 2007). Such engagement requires early consultation with local groups and the wider public to ensure that views are identified, assessed and incorporated (where necessary) into site master planning early on,

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or upstream, in the development process (SU BRIM Project, 2008), and to ensure wider social, environmental and economic benefits are fully realized (Cundy et al., 2013). Understanding public perception toward the local site, and to contaminated site management more generally, is essential in this process (e.g. Harclerode et al., 2016). Many subjective/emotional perceptions however are not directly measurable or easily collected, and so may not be included effectively in the planning and development process.

Application of structural equation modeling may address this problem. Structural equation modeling (SEM) is founded on statistical methods that test validities of a theoretically/conceptually-conceived model linking qualitative perceptive responses such as public perception to readily definable and measurable parameters. The method has been utilized to answer research questions in psychology (Carpita and Ciavolino, 2014; Ko and Stewart, 2002; Trzeciakowski et a1., 2014), environmental sciences (e.g. Eisenhauer et al., 2015; Santibáñez-Andrade et al., 2015; Levêque and Burns, 2017) and marketing (Subramanian et al., 2014). For example, in the environmental sciences, Eisenhauer et al., 2015 reviewed the application of SEM in the general ecology (and soil ecology) literature, modeled multivariate relationships between hypotheses and observed data, tested mediation of multiple variables, and gave examples of the potential use of SEM in allowing a shift from describing ecological patterns to gaining an improved mechanistic understanding of ecological variables. Santibáñez-Andrade et al., 2015 used SEM to evaluate the direct and indirect causes of degradation in the forests of the Magdalena river basin of Mexico City, by linking environmental indicators on the structure, composition and function of the ecosystem. Few studies however have been carried out in the field of public perceptions toward site remediation practices, although Hou et al. (2014a) employed factor analysis (FA) in structural equation modeling to identify influences of qualitative latent factors such as sustainability considerations, benefiting and impeding institutional forces, and stakeholders' influence, in contaminated land remediation.

In our research, structural equation modeling is applied to delineate how the public perception of actions taken during contaminated site mitigation is driven by latent exploratory variables, using brownfield redevelopment sites in China as a test case. In turn, each latent variable is represented in a measurement submodel consisting of readily measurable factors. Data were collected through questionnaire surveys conducted at four active remediation sites in China, and are used to validate the model. Public perception is represented by multivariate relationships among exploratory variables including the extent of information disclosure, outreach and education, the degree of public participation, satisfaction with the outcomes of remediation and redevelopment, understanding of site remediation policies and management, and knowledge of soil pollution.

2. Methodology

2.1. Exploratory variables

A four-part questionnaire was designed to measure 22 factors (Table 1) which have been previously argued to characterize public perceptions towards contaminated site management (Cundy et al., 2013; Eiser et al., 2009; Feldman and Hanahan, 1996; Grasmück and Scholz, 2005; Greenberg and Lewis, 2000; Li and Tan, 2012; Scholz and Siegrist, 2010; Tonin et al., 2011; Vandermoere, 2008). The first part of the questionnaire collected socio-demographic information on the subjects including gender, age, education, occupation, household size, income, and duration of residence. The second part encompassed factors characterizing exploratory variables related to the subjects' knowledge of soil pollution at the contaminated site (SP), namely understanding of soil pollution (X1), hazards of pollutants (X2), severity (X3) and causes (X4) of pollution, and willingness for relocation (X5 - symbols inside the parentheses denote the abbreviated notation for each factor in the SEM, summarised in Table 1). The third part included 11 questions with choices of yes/no/neutral answers, measuring:

(1) Factors characterizing exploratory variables related to subjects' satisfaction with authorities' information disclosure (ID), ranging from X6 to X10 (Table 1);
(2) Factors characterizing exploratory variables related to public outreach and education (OE), ranging from X11 to X13 (Table 1);
(3) Factors characterizing exploratory variables related to public participation, ranging from X14 to X16 (Table 1).

The final part of the questionnaire examined factors characterizing exploratory variables related to:

(1) Subjects' familiarity with management policies of the contaminated site (PS), including factors characterizing whether or not to solicit public insight (X17), willingness to learn about policies (X18), and satisfaction with policies in damage compensation, dissemination of information and sustainable remediation (X19);
(2) Public desire to support the project (RE), including opinions on willingness to pay for contaminated site remediation (X20), satisfaction with alternative reuse possibilities (e.g., housing, recreation, agriculture) (X21), and willingness to purchase houses built on remediated sites (X22).

2.2. Survey protocols

The four sites surveyed were a coking plant in Beijing, a pesticide factory in Hangzhou, a nitrogen fertilizer factory in Guangzhou, and the Disney development project in Shanghai (all in China). All sites were undergoing active redevelopment or remediation at the time of the survey (Table 2).

Those residents living in a radius of 200 m from each contaminated site, following findings from our earlier surveys (Li et al., 2016), were more vocal about, had stronger opinions toward, and paid more attention to, the progress of the remediation projects. Their perceptions would provide the most critical information for establishing the structural equation modeling. At each location, 110 subjects residing within the 200 m radius were randomly selected. In total, 412 sets of questionnaires (Table 3) were completed through face-to-face interviews.

The data were pooled for model verification as the respective socio demographic characteristics of the four locations were not significantly different. The summary statistics (Table 4) showed that the survey subjects were rather evenly divided between the male and female genders (47.1% vs. 52.9%). Collectively, the survey subjects of the four locations averaged 29 years old, 51.9% had completed high school, and 31.9% held baccalaureate or higher academic degrees. The majority of the interviewees were gainfully employed (70.2%) with the remainder being unemployed (7%), in schools (5.1%), or in retirement (17.7%). An average household consisted of 3.71 persons and 56% of the subjects had resided at their current address for 5 or more years. These were middle-low income neighborhoods, where 67.8% of the subjects earned less