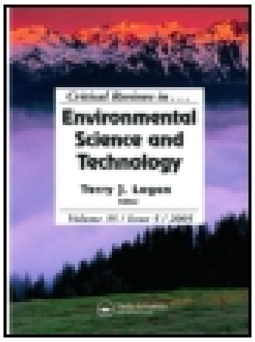

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Remediation in developing countries: A review of previously implemented projects and analysis of stakeholder participation efforts

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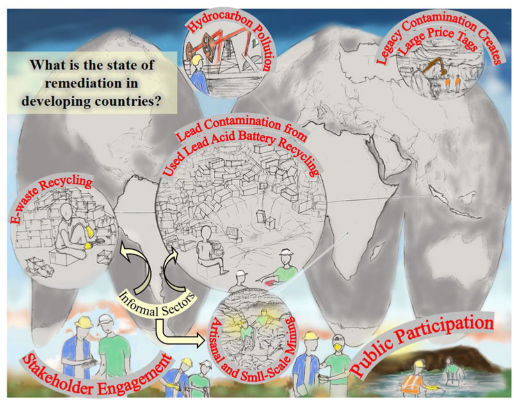
ABSTRACT

In developing countries, remediation projects are predominantly implemented in areas with imminent risks due to human exposure routes. Projects experience challenges due to funding constraints derived from the history of legacy pollution and informal livelihood occupations in addition to political and economic instability and weak regulatory structures. Remedial efforts therefore often utilize simple, cost-effective methods of excavation and safe storage of polluted media, most often of which is soil contaminated with heavy metals and persistent organic pollutants. Overcoming context-specific challenges require strong stakeholder participation efforts. However, most projects fail to effectively engage multiple stakeholders and suffer from inexperienced facilitation and inaccurately applied engagement methodologies. This literature review critically examines remedial projects in developing countries. Particular attention is given to remedial challenges specific to working in developing countries and current state of the practice of clean-up initiatives. It provides recommendations for enhancing existing remedial efforts by developing robust stakeholder participation efforts throughout the remedial process.



KEYWORDS Clean-up; contaminated land management; remediation

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Introduction

In 2010, lead contamination from artisanal and small-scale gold mining (ASGM) killed over 400 children in six months and exposed over 17,000 people to lead poisoning in northern Nigeria (Agence France-Presse, 2010; Tirima et al., 2016). Public attention to this epidemic spawned both medical and clean-up assistance for the impacted communities, resulting in a massive remedial effort to reduce ongoing lead exposures and develop Nigeria's capacity to prevent future catastrophes. Clean-up and capacity building efforts included lead removal, clean soil replacement, institutional controls, and health advocacy campaigns from various non-governmental organizations (NGOs) and government agencies worldwide (Tirima et al., 2016). Nigeria's 2010 lead poisoning crisis is far from the only example of the risks posed to human health and the environment due to pollution and contamination worldwide, much of which targets people in developing communities. In fact, in 2016, pollution-related diseases were the cause of premature death for over nine-million people in the world (World Health Organization, 2018). Of these nine-million deaths, approximately seven-million people died from exposure to indoor and outdoor air pollution, and an additional two million died due to a combination of unsafe drinking water, sanitation practices, and unintentional poisonings: the result of exposure to hazardous chemicals and environmental contamination (World Health Organization, 2018). These high mortality rates prompted the creation of one of the World Health Organization's Sustainable Development Goals to substantially reduce "the number of deaths and illnesses from hazardous chemicals and air, water, and soil pollution and contamination by 2030" (World Health Organization, 2018).

Ninety-two percent of pollution related mortality occurs in low- and middle-income countries, threatening poor communities around the world (Hardoy et al., 2001; Landrigan et al., 2018). This is due, in part, to unsafe work practices, technological barriers (Evans & Kantrowitz, 2002; Lupi & Hoa-Nghiem, 2015), socioeconomic tradeoffs (Atash, 2007; Bartrem et al., 2014; Evans & Kantrowitz, 2002; Hilson, 2002; Raza et al., 2017), political instability (Bartrem et al., 2014), poor appropriation of funds (Atash, 2007; Lupi & Hoa-Nghiem, 2015; Müezzinoğlu, 2003), and insufficient capacity for regulation and supervision from government and local institutions (Atash, 2007; Beckers & Rinklebe, 2017; Lupi & Hoa-Nghiem, 2015; Müezzinoğlu, 2003; Tirima et al., 2016). Vulnerabilities created by these factors ultimately result in disproportionate exposure to contamination (Evans & Kantrowitz, 2002; Raza et al., 2017). Thus, there is an urgent need to implement strategies to both prevent and clean-up contamination in these regions.

Remediation, the removal of hazardous contaminants from soil, groundwater, sediment, and surface water, provides an opportunity to reduce pollution and, thereby, pollution-related deaths (Landrigan et al., 2018; World Health Organization, 2018). Although remedial efforts have occurred in developing communities, such as the clean-up of lead contamination in Nigeria in 2010, most efforts have been confined to developed communities due to the difficulty in overcoming the above-mentioned barriers (e.g., social, economic, etc.). Efforts specifically focused on developing communities have often been poorly documented or communicated. Published literature has largely focused on improving remedial technologies and strategies (Garelick et al., 2005; Li, 2010; Li et al., 2012; Phillips, 2009) rather than examining the implementation of these strategies within the communities themselves (Erakhrumen, 2011). Additionally, little analysis has been performed in an effort to synthesize our understanding of context-specific issues that may differ from projects in industrialized nations.

Previous studies on other environmental projects in developing communities, such as water treatment, highlight the importance of stakeholder engagement and participation to a project (Luyet et al., 2012; Reed, 2008). As demonstrated by Reed (2008), stakeholder engagement and participation fosters solutions that can be adapted to a local sociocultural context. Additionally, stakeholder engagement can uncover health and environmental information that may not be immediately evident from traditional techniques of environmental sampling and field testing by integrating local knowledge with technical knowledge. For remediation projects, specifically, this knowledge blending can reveal existing contamination and priorities to local community members, whose context-dependent knowledge results from collective experience, often derived through observation (Reed, 2008). In other words, community members can be important sources of information in remediation projects. In this paper, we distinguish between stakeholder engagement and stakeholder participation, following the definition of participation from The World Bank. Stakeholder participation is a "process through which stakeholders influence and share control over development [in this case, remediation] initiatives and the decision and resources which affect them" (Luyet et al., 2012; World Bank, 1996). By comparison, stakeholder engagement represents a broader collection of activities that encompasses stakeholder participation, but also includes activities such as consultation and active listening whereby stakeholders do not necessarily influence decisions. Rather, these activities provide information to decision-makers. These nonparticipation activities are important initial steps in a project that can lead to stakeholder participation. However, because actual stakeholder participation results in greater ownership and sustainability of projects (World Bank, 1996), it is worth distinguishing from broader stakeholder engagement efforts.

The purpose of this work is to understand both the barriers and opportunities of environmental remediation projects performed within the social, economic, and political context of developing communities. Results can be used as both a reference for remediation practitioners working in developing communities and a roadmap for future efforts. After a brief explanation of the methods used in this review, we classify previous efforts by contaminant, industry practice, project cost, and remedial strategy. The results of this classification expose a need to analyze stakeholder engagement and participation within the remediation projects. In addition to environmental remediation, findings can be applied to other intervention efforts in developing countries, particularly those that require behavior changes from community members and local acceptance of project activities.

Methods

Environmental remediation efforts (hereafter referred to as *remediation projects*) in developing countries are often conducted by national governments, sometimes in collaboration with local authorities and NGOs. Information on these projects is typically reported in unpublished reports or project webpages, and little to no information is available in the form of peer-reviewed literature. Consequently, this review combines both peer-reviewed literature and gray literature in the form of websites and unpublished reports from NGOs or government authorities. For a clean-up effort to be included in this review, a formal document, either in the form of a project report, article, working paper, or a summary web page must be available.

This review targets implemented remediation projects in developing communities. Therefore, the review excludes studies involving the following:

1. preventive strategies for pollution, instead of remedial processes for existing contamination;
2. policy and governmental capacity building;
3. existing and emerging remedial technologies but do not address practical applications within a developing country context;
4. a project location exclusively in China.

Because there are several literature reviews focused specifically on remedial efforts within China, we excluded projects located in China alone from this review (Li et al., 2017; Sun et al., 2018; Tang et al., 2016; Xie & Li 2010). These reviews concluded that policy improvements in China can enhance existing contaminated site management efforts, such as remediation, as well as greater inclusion of stakeholders and the public in projects.

We used several methods to identify remediation projects. For example, we conducted two different Web-of-Science queries. The first search returned 350 results by using the search terms "remediation," "clean-up," "contaminated land," and "developing countries." The second search returned 1125 results by using the search terms of "remediation," "clean-up," "contaminated land," "polluted ground," "polluted land," and "polluted soil," excluding results with "experimental study," "pilot-scale" and "field study." After reading all abstracts from these two searches, we excluded most of the papers because the focus was on policy, technological advances at the laboratory scale, or field trials of a technology rather than actual clean-up. Other articles were excluded because the authors used samples taken from a developing country for laboratory analysis, but no follow-on remedial efforts were included. We also searched the project repository from the Global Environment Facility (GEF) and the World Bank using the search terms mentioned above, resulting in six additional projects. Excluded projects from the GEF and World Bank searches mentioned remediation but rather focused on policy related to the environment or mining reclamation.

The majority of remediation projects were found through searching the project repository on the Pure Earth website. Pure Earth is an NGO focused on reducing pollution-related health risks though environmental clean-up in developing communities and is therefore involved in many remediation efforts around the world. Specifically, Pure Earth was involved in some capacity in about 70% of the projects covered in this review. We reviewed all 159 "Completed Projects" listed on Pure Earth's website (as of September 24, 2019). From this list, 29 projects were included based on the above-mentioned criteria. Finally, the citations contained in each of the sources were checked for additional studies or reports that were not found in the preceding search. One additional project was found (through a citation to a government website). Overall, we identified 38 relevant projects from 20 countries (Figure 1).

It is important to note the limitations of this work due to the limited literature available on remediation projects in developing countries. Unlike developed countries, there are no standardized reporting requirements for projects. Therefore, although well intentioned, many documents were missing key details (like the type of contaminant being targeted) or contained vague language to describe the remedial strategy. Our other classifications of project cost and responsible sector faced similar barriers during analysis. In addition to limiting the review, poor project reporting propagates confusion for practitioners seeking information about a specific contaminant and applicable remedial technologies for future remedial efforts.

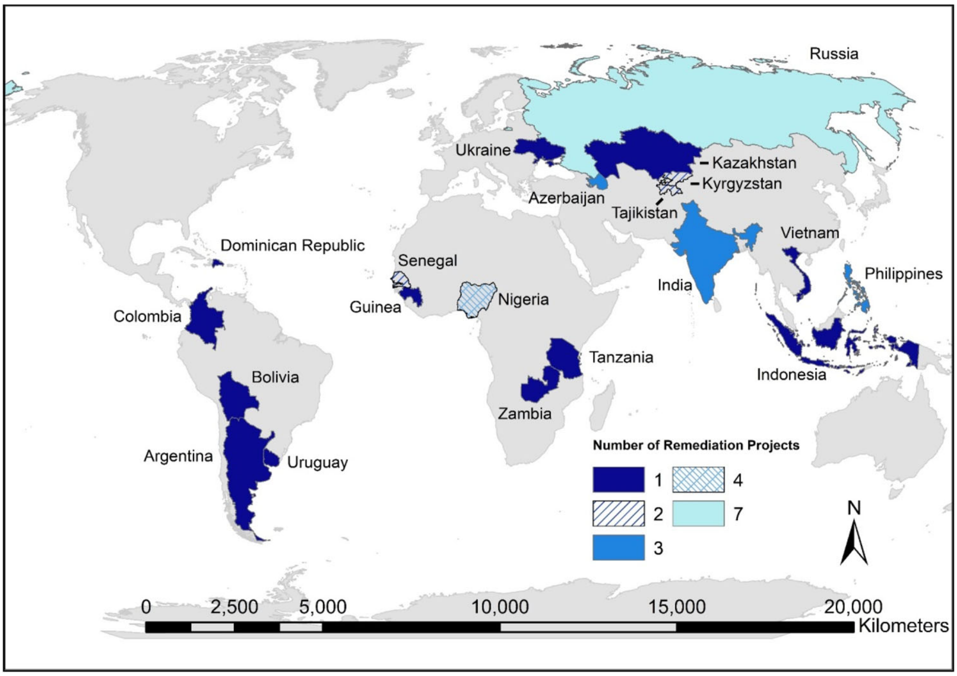

Figure 1. Map showing the location and number of remediation projects included in this report. The color scale corresponds to the number of projects identified in each country. Data source: ArcWorld Supplement for continent shapefiles and Esri, Garmin for country shapefiles. The map was created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved.

Project classifications

To understand the state of remediation in developing countries, projects were first identified by contaminant, responsible sector, project cost, and remedial strategy. Overall, the projects spanned 23 different contaminants from over 14 different sectors, and a wide range of costs and clean-up efforts.

Contaminant categories

Figure 2 shows remediation projects based on contaminant category. Projects targeted heavy-metal contamination, persistent organic pollutants (POPs) (e.g., dichlorodiphenyltrichloroethane (DDT), polychlorinated biphenyls (PCBs), and other pesticides), hydrocarbons (e.g., crude oil or benzene), and radionuclides. Other contaminants included tannery waste, aluminum, cyanide, and fluoride. Notably, lead was targeted in 13 remediation projects, more than double any other contaminant. This was due, in part, to the known health effects of acute lead poisoning (Blacksmith Institute, 2007a; Haefliger et al., 2009; Tirima et al., 2016). Moreover, in

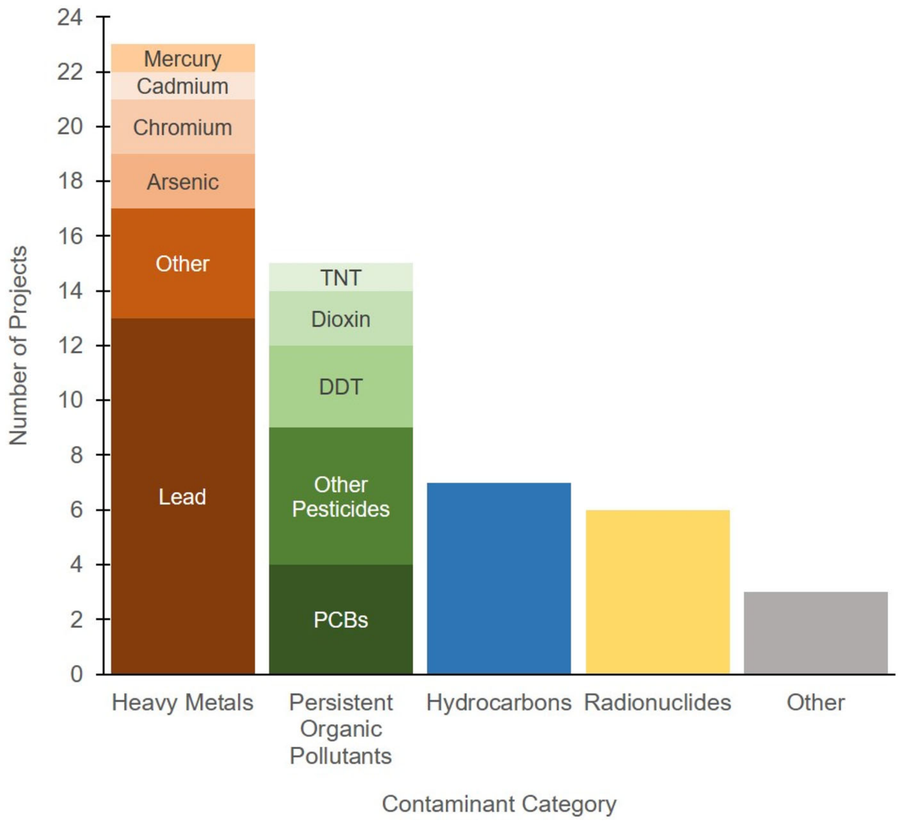

Figure 2. Number of remediation projects sorted by targeted contaminant, representing 23 different contaminants. Heavy metals and Persistent Organic Pollutants (POPs) are segregated into more specific contaminants due to differentiation within project reporting. Radionuclides consist of cesium, strontium, plutonium, and uranium contamination (approximately one project each). Other contaminants include tannery waste, aluminum, nickel, cyanide, and fluoride.

communities with used lead-acid battery (ULAB) recycling, lead contamination critically endangered the local population because of the proximity of lead operations to households, schools, and public gathering spaces (Blacksmith Institute, 2014b). In fact, except for one project that did not provide enough information to be evaluated (UNDP, 2016), all lead remediation projects reported successful completion of the clean-up effort. Similarly, contaminants such as DDT and mercury motivated remedial efforts when in proximity to a human population.

Responsible sectors linked with project cost

Although remediation projects are critical endeavors for the health and well-being of local communities, knowledge of responsible party(s) (or lack thereof) often limits implementation and support. The majority of contamination targeted by previous remediation projects originated from four broad categories: mining, recycling, chemical-related industries, and other sectors. Table 1 delineates these sectors into more specific activities within each category. The third column lists the various contaminants due to the corresponding activities, with citations to project reports and other literature. Most of these sectors are affiliated with some of the world's most polluting industries of nonferrous metal production and industrial chemicals (Binder, 2001; Mani & Wheeler, 1998). However, work in these sectors has developed beyond traditional mining and manufacturing of products to include low-income individuals and small-groups informally engaged in recycling activities of used products. These sectors include artisanal and small-scale mining (Environmental Law Institute, 2014), electronic waste (e-waste) recycling (Ackah, 2017), and ULAB recycling (Daniell et al., 2015). Six projects (16%) in this review targeted contamination caused by an informal sector (Figure 3).

Although informal sectors, such as ASGM and ULAB recycling, contributed to contamination, 58% of the projects targeted legacy contamination from formal operations (Figure 3). Legacy pollution results from historic activities where the responsible parties are either unknown, bankrupt, or now-obsolete state agencies (World Bank, 2011a, 2012). Working with this definition, projects were classified as "legacy contamination" if the responsible party was unknown, did not perform remediation, or was not held liable for the contamination. Of the legacy remedial sites, 40% were attributed to the mining industry. Due to poor project reporting, 11% of the projects failed to specify the responsible sector and therefore could not be classified as legacy or non-legacy contamination (Blacksmith Institute, 2005b, 2014d; CSIR-NEERI, 2015; Pure Earth, 2018c).

In terms of remedial costs, only 60% of projects reported total project cost, the majority of which were classified as legacy contamination (Figure 3). Sixty-six percent of projects with legacy contamination had a project cost over 100,000 USD, four of which cost over 1,000,000 USD. As highlighted by the World Bank (2004), municipalities and national governments lack the financial resources and economic stability to support these legacy projects with high price tags, creating a funding barrier for remediation projects. Due to the high clean-up costs from legacy contamination and the inability to hold responsible parties accountable, outside funding from organizations such as the Global Environment Facility (GEF) and the United Nations Development Program, among many others, supported over 60% of the projects in this review.

Informal sectors experienced similar funding barriers for remediation projects due to the informal nature of their operations and a lack of regulatory mechanisms required to hold them accountable. The average cost of remediation projects targeting informal contamination was approximately

Table 1. Activities responsible for contamination in reviewed remediation projects. Four broad categories of mining, recycling, chemical-related industries, and other sectors are further delineated into more specific activities within each category. The third column lists the various contaminants due to the corresponding activities, with citations to project reports and other literature.

Sector categories for contamination	Specific activities within each sector	Contaminant and citations
Mining	Large and Medium-Scale Mining Activities	Lead (Blacksmith Institute, 2014c; Ericson & Dowling, 2016; Sharov et al., 2017), Mercury (Pure Earth, 2017b), Radionuclides (Blacksmith Institute, 2014e; Ferl, 2017; Pure Earth n.d.a), Unspecified Contamination in Copper Tailings (World Bank, 2004)
	Artisanal and Small-scale Gold Mining	Lead (Tirima et al., 2016)
	Smelting Activities	Lead (Blacksmith Institute, 2008a, 2009; Pure Earth, 2017a)
Recycling	Used lead-acid battery recycling (ULAB)	Lead (Blacksmith Institute, 2008c, 2009, 2014b; Pure Earth, 2016; UNDP, 2016)
	E-waste recycling	Lead (Pure Earth, 2015b)
Chemical-Related Industries	Chemical and Explosives Manufacturing	Benzene (Pure Earth, 2015a), Benzo [a] pyrene (Pure Earth, 2015a), Chromium (Blacksmith Institute, 2006a), Lead (Blacksmith Institute, 2006a), Mononitrochlorobenzene (Blacksmith Institute, 2014a), PCB (Pure Earth, 2015a), Radionuclides (Pure Earth, n.d.a), TNT (Blacksmith Institute, 2014a)
	Chemical Weapons Dismantling	Arsenic (Blacksmith Institute, 2008b), Dioxin (Blacksmith Institute, 2008b), Lead (Blacksmith Institute, 2008b)
	Pharmaceutical Industry	Aluminum (Blacksmith Institute, 2005a), Cyanide (Blacksmith Institute, 2005a), Lead (Blacksmith Institute, 2005a, 2009), Nickel (Blacksmith Institute, 2005a), Unspecified POPs (Blacksmith Institute, 2005a)
	Leather Tanning	Arsenic (Blacksmith Institute, 2009), Cadmium (Blacksmith Institute, 2009), Chromium (Blacksmith Institute, 2009)
Other Sectors	Oil and Gas Industry	Hydrocarbons (Chikere et al., 2017; Ola et al., 2018; UNEP, 2011; World Bank, 2007), Radioactive Waste Oil (MES, 2008)
	Military Operations	Dioxin (Lupi & Hoa-Nghiem, 2015), Lead/other Heavy Metals (Blacksmith Institute, 2007b), PCB (Blacksmith Institute, 2007b)
	Abandoned Capacitor	PCB (Pure Earth, 2018b)
	Nuclear Reactor	Radionuclides (Devell et al., 1986; Pure Earth, n.d.b)
	Pesticide Storage Facility	DDT (Blacksmith Institute, 2006b, 2011; Pure Earth, 2017c), Unspecified Pesticides (Blacksmith Institute, 2006b; Pure Earth, 2018a)
	Unspecified	Fluoride (CSIR-NEERI, 2015), Tannery Waste (Blacksmith Institute, 2005b), Unspecified Heavy Metals (Blacksmith Institute, 2014d; Pure Earth, 2018c), Unspecified Pesticides (Pure Earth, 2018c)

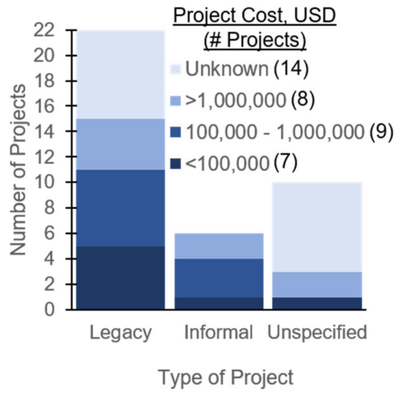

Figure 3. Remediation projects sorted by whether the project targeted legacy contamination or was caused by an informal sector. These categories are further partitioned by project cost as reported by the available project reports.

80,000 USD. Three of the projects cost between 100,000 and 1,000,000 USD, and two projects cost over 1,000,000 USD (Figure 3). Development agencies, such as the United Nations, World Bank, and Asian Development Bank, were the financers of such clean-up efforts.

The dependency on development agencies further demonstrates the contexts of economic fragility, political instability, and regulatory vulnerabilities in which projects operated. For example, two of the projects classified as "unspecified" (i.e., not legacy or informal) still cost over 1,000,000 USD (Figure 3). Both of these remedial initiatives were part of larger projects that simultaneously sought to strengthen regulatory capacity within the countries, restructure or improve the responsible state-controlled extractive companies, and provide needed financial resources that were otherwise unavailable (World Bank, 2004, 2007). In fact, during rehabilitation of the Uzen Oil Fields in Kazakhstan, remedial activities were not originally planned. Instead, they were added onto existing project activities based on technological availability and potential profitability (World Bank, 2007).

Remedial strategies

From the thirty-eight projects, fifty different remedial strategies grouped into four main categories were employed to clean-up twenty-three different compounds (Figure 4). Projects targeted all environmental media, including water (30%), soil (78%), and air (7%). The most common remedial strategy applied was excavation and safe storage (a source recovery and removal method), where contaminated soil was physically removed and stored in an alternate location, typically off-site. Encapsulation, in which soil is surrounded by impermeable barriers in situ, was the only method that applied isolation and containment as a remedial strategy. Four projects explored

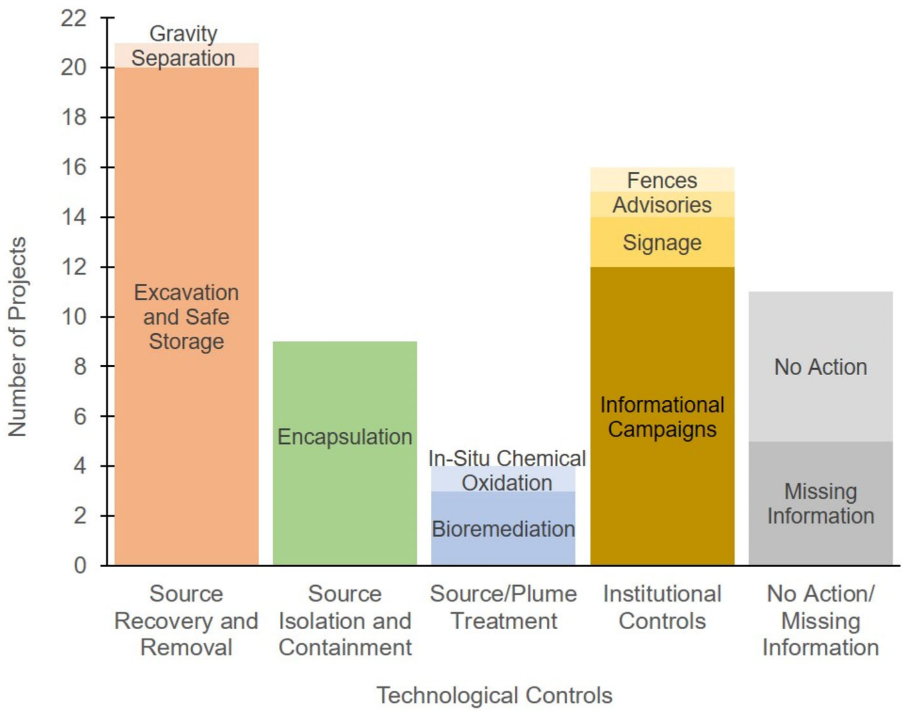

Figure 4. Remediation projects sorted by employed remedial strategy. Projects often utilize more than one remedial strategy. Therefore, the total number of remedial strategies (50) exceeds the 38 projects included in this report. The category of Missing Info identifies projects that lacked enough information in the report to identify the remedial strategy employed. The category of No Action identifies projects that never employed a remedial strategy due to various barriers to implementation.

source and plume treatment options such as bioremediation or in-situ chemical oxidation. As previously discussed, many projects targeted lead remediation using source recovery and removal (i.e., excavation and safe storage). The utilization of excavation and safe storage requires an appropriate storage method for the hazardous waste to reduce the risk of recontamination. For example, during a pesticide clean-up in Azerbaijan, Pure Earth selected a hazardous waste facility location "situated away from any residential areas," and used appropriate containment measures such as concrete lined pits and the overpacking of liquid pesticides in plastic (Pure Earth, 2018a). Proper containment reduces the risk of recontamination by preventing groundwater migration (Lombi et al., 1998). In the event the containment fails, locating the hazardous waste facility away from people reduces the risk of contaminant exposure. However, a hazardous waste disposal facility may not be available. For example, during the remediation of mercury-contaminated soils in Kyrgyzstan, contaminated soil was stored at a nearby tailings facility (Pure Earth, 2017b). Disposal location selection is critical to the success of projects that utilize excavation and safe storage.

When a hazardous waste storage facility is not available, other options may need to be considered, including other remediation technologies (for a discussion on different remediation technologies see Lombi et al. (1998) and Li (2010)).

Many projects implemented institutional controls alongside other remedial strategies. Institutional controls included dissemination of information through mass media outlets, informational pamphlets or children's books, and educational programs and workshops created for communities and schools. Fourteen projects (∼40%) utilized institutional controls as part of the remedial activities. Institutional controls rely on the adoption and compliance of local communities to be effective, necessitating adequate stakeholder participation efforts (US EPA, 2012). Yet, out of these fourteen projects, four failed to document any form of stakeholder engagement, and only two noted collaboration with local governmental authorities. Four other projects noted some kind of coordination with the local community but lacked evidence to suggest that local community members actively participated within the remedial process. For example, during the Nigeria Lead Poisoning Crisis described earlier in this review, two institutional controls were implemented. One prohibited the employment of women in ore processing, and the second required active artisanal miners to remediate any re-contaminated media from their activities (Tirima et al., 2016). However, there was no information describing whether community members complied with these institutional controls or how cooperation with local community members created these institutional controls. Because the investigated projects lacked analyses and reflections on stakeholder engagement or participation, the effectiveness of institutional controls could not be evaluated, and insights on the proper utilization of institutional controls could not be determined from these projects.

Stakeholder and community participation

Because stakeholder engagement and participation is an important component in creating effective solutions in environmental projects (Chess & Purcell, 1999; Luyet et al., 2012; Reed, 2008), the investigated remediation projects were analyzed against criteria for effective stakeholder participation developed by Reed (2008): engagement and acknowledgement of a diverse range of stakeholders, skilled facilitation of stakeholder engagement and participation efforts, and early engagement and continuous participation of impacted stakeholders. For the projects investigated, stakeholder participation efforts that included multiple groups were limited. Forty-four percent of the projects failed to document any stakeholder engagement or participation. Twenty-one percent of the projects listed some kind of local government collaboration but failed to note any additional stakeholder engagement or participation in the project. Only thirty-two percent of the projects reported diverse stakeholder engagement, which included activities such as creating stakeholder groups or committees, community mapping, and household surveying. We did not consider education and informational campaigns delivered to local community members to be a form of stakeholder engagement since these activities are types of institutional controls, discussed previously. Moreover, only four projects (10%) provided evidence of involving local community members (individuals not necessarily part of an NGO, governmental authority, or other institution). Three of these four projects utilized a stakeholder group for stakeholder participation, and one project utilized a combination of consultations and workshops. Only one project mentioned the use of stakeholder mapping to identify the impacted stakeholders in the project (Blacksmith Institute, 2005b). Overall, projects often failed to document details about stakeholder engagement within reporting. This included a failure to provide or explain initial stakeholder analysis to ensure all impacted stakeholders were, at least, engaged in the project. Given the limited information available, the following excerpts and discussion summarize existing stakeholder engagement and participation efforts.

Poor stakeholder participation, often caused through inadequate facilitation, led to project delays and failure. For example, in the Msimbazi River project in Tanzania, several stakeholder groups were involved in pursuing clean-up efforts for heavy metal and pesticide contamination, but the project did not leverage the collective action of the various groups and the remedial efforts were left incomplete:

> efforts [of the various stakeholder groups] are isolated … and primarily prevent further contamination more than remediate the problem such that it currently exists. It is necessary at this point to synchronize the efforts of all interested parties, to maximize their overall effect … The community stakeholders know best the history of their surroundings and the sources of the water pollution. But, due to lack of efficient communication channels to the government, this resource has previously not been effectively utilized (Pure Earth, 2018c).

While local stakeholders were equipped with knowledge on local environmental conditions, without proper coordination and facilitation of these groups, this knowledge could not be properly leveraged to assist with remedial efforts. Poor coordination further contributed to confusion about responsibility: in the Msimbazi River project, community stakeholders considered the river clean-up to be the government's responsibility. As a result, they hesitated to take action, stalling remedial efforts. By comparison, adequate facilitation of stakeholder participation drove greater project success. During the remediation of heavy metals and PCBs in the Clark and

Subic Bay area of the Philippines, Pure Earth coordinated the utilization of a stakeholder group, local technical experts, and staffed local partners to monitor day-to-day operations of the project. This allowed multiple institutions and groups to direct project activities in varying ways: local institutions provided additional evaluation of remediation proposals, local technical experts recommended sampling locations and site selection, and the stakeholder group—made up of local community members, local government, and redevelopment authorities—helped to facilitate project management over the course of remediation activities (Blacksmith Institute, 2007b). In addition to including a diverse range of stakeholders in the project, the ability to manage and direct these diverse stakeholders' efforts led to effective sampling and site selection, efficient clean-up of contaminated soil, and the scheduling of thirteen additional contaminated sites for remediation (Blacksmith Institute 2007b).

In addition to the need for skilled facilitation and inclusion of a diverse selection of stakeholders, defining common goals and expectations for a project required early engagement and continuous participation of all stakeholders (Chess & Purcell, 1999). In the previous example of remediation in Clark and Subic Bay, early engagement of local officials and technical experts produced effective sampling procedures and established communication early among different stakeholders. Additionally, local community members and government officials understood the existence of contamination near them and supported project activities (Blacksmith Institute, 2007b). Because these stakeholders were also given responsibilities pertaining to remedial efforts, communication continued as all stakeholders actively participated in project activities. By contrast, failure to engage stakeholders early in project activities resulted in miscommunication and project failure during a World Bank-sponsored project in Bolivia. Project authorities removed funding for remediation of contaminated mine sites within two years of the project start date due, in part, to a lack of agreement from the community on the proposed solutions (World Bank, 2004). Over 3 million USD, allotted for remedial activities, were either transferred to pay for laboratory upgrades, used to create technical assistance programs for municipalities affected by mining, or were canceled altogether. An additional 3 million USD were further spent on studies that did not result in a remediation project (World Bank, 2004).

One project assessed, in detail, the methods of its stakeholder participation and effectiveness of these processes, demonstrating how early engagement without continuous participation may compromise project success. The Copperbelt Environment Project in Zambia utilized a detailed stakeholder participation plan and envisioned utilizing stakeholders in the identification, selection, and design of remedial subprojects. A Midterm Review workshop convened 62 different stakeholders to discuss the project part-way through implementation, and stakeholder consultations continually provided feedback to the project (World Bank, 2011b). Unfortunately, portions of the project team failed to recognize community participation as an essential component of the remediation project, arguing that a "community component would make this already very ambitious Project [sic] too complex and implementation possibly even slower" (World Bank, 2011b). While the local community was intended to be included in selection and identification of subprojects, the technical environmental coordination unit made most of these decisions. During the Midterm Review, community members provided feedback to project members, but did not actively participate in decision-making that directed project activities. Thus, while local community members were involved early in the project and allowed to provide recommendations, they did not implement remedial subprojects as the project had envisioned. At the conclusion of the remedial activities, the project reported limited sustainability and local ownership of clean-up efforts because local communities did not actively participate throughout the remedial process.

Overall, some remediation projects struggled in effectively facilitating diverse groups of stakeholders and allowing active participation of stakeholders throughout the entire remediation process. By comparison, other projects prospered when efforts were made to include stakeholders. They experienced success when diverse groups of stakeholders were engaged early in planning phase of the remediation process. In many cases, even if full stakeholder participation was never reached, early engagement and skilled facilitation of stakeholders still led to enhanced communication and the creation of shared goals, knowledge, and expectations among the various stakeholders.

Conclusions

Driven by a need to reduce or eliminate human exposures to hazardous contaminants, remediation projects play a critical role in maintaining the health and quality of life for developing communities. This review synthesized information from 38 implemented remediation projects in developing countries, both from academic and gray literature. Remediation projects primarily targeted contamination of soil media due to heavy metals (the majority of which were lead contamination), followed by persistent organic pollutants. Due to the dominance of soil contamination within the remediation projects, source recovery and removal strategies were the primary method of clean-up, despite concerns about long-term contamination resulting from ineffective storage solutions. Three main sectors were responsible for contamination: mining, recycling activities, and chemical production. Over seventy percent (70%) of the projects were due to either informal livelihood occupations or legacy pollution, the majority of which were classified as legacy pollution. The dominance of legacy pollution and informal livelihood occupations in remediation projects created a funding and responsibility gap specific to developing countries because of limited governmental capacity to regulate and clean-up this kind of contamination. Development organizations therefore provided funding and support for remediation, and projects operated in fragile contexts that required commitment from local stakeholders to be successful. Additionally, many projects employed a series of institutional controls as part of the clean-up solution. Institutional controls relied on compliance and participation from the public, offering additional support to include local stakeholders within project activities.

Because remediation projects relied on cooperation between remediation practitioners and local stakeholders, we analyzed stakeholder engagement and participation efforts within the projects, finding a lack of strategic and successful engagement efforts. Overall, the investigated projects ignored stakeholder engagement and participation as a core part of the remediation process. When some form of stakeholder participation or engagement was present, project delays, wasted financial resources, and project abandonment were due, in part, to failed stakeholder participation efforts. Efforts were hampered due to a lack of skilled facilitation, inability to engage stakeholders early in project activities, or neglect of stakeholder participation throughout the entire project. By contrast, projects that more successfully pursued stakeholder participation experienced enhanced communication between different stakeholders, acknowledgement of shared goals and resources, and identified additional information pertaining to project activities.

Poor documentation of historic remedial efforts in developing countries continue to present a challenge for future projects and practitioners because of an inability to learn from past failures and successes. Thorough and accessible reporting, even if unpublished, is necessary for remediation projects to improve in the future, both in technical feasibility and stakeholder participation. Finally, this lack of documentation presents uncertainty in evaluating the effectiveness of remediation efforts.

Drawing from other development fields, stakeholder participation can begin with an initial "community appraisal" that asks a series of questions to identify sociocultural, technical, economic, political, environmental, institutional, and educational factors within a local community (Amadei, 2014). These efforts can be complemented with stakeholder analysis to ensure all impacted stakeholders are identified and engaged early in the remediation process. After an initial community appraisal is completed, individuals leading a remediation project can select appropriate engagement strategies to enlist local community members and other stakeholders within the project, ensuring the empowerment of different stakeholder groups to make decisions and contribute to the remediation project for its entire duration (Reed, 2008). We further recommend that future work explores a framework for incorporating diverse stakeholder engagement and participation within remediation projects. This framework can expand upon the criteria developed by Reed (2008) for effective stakeholder participation and apply it toward remediation. These criteria, used in this study to analyze remediation projects, include the engagement and acknowledgement of a diverse range of stakeholders, skilled facilitation of stakeholders, early engagement of stakeholders at the beginning of a remediation project, and continuous participation of stakeholders throughout remediation. Especially for projects utilizing institutional controls or operating in an area with informal livelihoods, remediation projects must employ strategic, informed stakeholder participation efforts to reveal context dependent solutions that ensure the health, well-being, and development of communities in developing countries.

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Conflict of interest

Rosalie M. O'Brien, Thomas J. Phelan, Nicole M. Smith, and Kathleen M. Smits declare that they have no conflict of interest.

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