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## ASSESSING COMMUNITY PERCEPTION OF POST-MINE BROWNFIELD'S EFFECTS ON THE PHYSICAL ENVIRONMENT IN KISUMU, KENYA

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### ABSTRACT

*Urban development has overtime spread into areas where mining/quarrying activities were once carried out. This has resulted into presence of degraded landscapes referred to as post-mine brownfields within the urban landscape. Brownfields constitute a poor fit into the urban realm and are considered as problem spaces. They are a safety concern due to crime and hazards associated with abandoned sites. They also take up vital urban land that could be used more productively, besides not being aesthetically appealing to residents of the neighborhoods. While there is need to rehabilitate Kisumu's brownfields into more productive urban land uses, public perception of the effects of these sites on the living environment is not clearly understood. In accordance, this study postulates that rehabilitation of post-mine brownfields lies in understanding the effects they pose within the neighborhoods they are found in and which should not be neglected. The purpose of this paper was to assess the public perception of the effects of post-mine brownfields on the physical environment in Kisumu. Cross sectional research design was used, with the unit of analysis being the brownfields and households living within a 500-metre radius of each brownfield site. A total of 96 willing participants selected randomly were involved in the survey within four brownfield neighborhoods that were purposively selected in the study due to long history on quarrying thus resulting into post-mine brownfields. The survey used questionnaires and the findings were analyzed using percentages and presented in tables. The study found out that the post-mine brownfields were characterized by waterlogging and illegal dumping of wastes, which presented health hazards within the residential neighborhoods they were sited in. Since the sites are currently used as illegal dumpsites, the study recommends that alternative waste management practices would need to be planned for. The findings should inform both policy and practice on the rehabilitation of post-mine brownfields in Kisumu City.*

**Keywords:** *Community perception, Post-Mine, Post-mine brownfields effects, Physical environment identities, mining activities, quarrying activities, degraded landscapes, urban landscape*



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## INTRODUCTION

Mining is regarded as a crucial economic activity all over the world. It is however associated with significant negative impacts on the environment that affect the ecological, social and aesthetic integrity of the landscape. The negative effects include destruction of the topography, degradation of soil, loss of natural flora and fauna (Mert, 2019); Loures et al., 2015; Kuter, 2013). According to Arbogast et al (2000), increased demand for construction materials such as sand, gravel, crushed stone, dimension stone and clay due to urbanization that is rapid greatly changes the landscape and as such largely considered to be harmful to the environment. Brownfield geographical context, according to Frantal et al. (2012), shows that developed countries such as US, Great Britain, France and Germany have long experience with the problems of brownfields, which had already emerged during the 1970's as a result of massively declining mining industries. According to Russ (2000), in the United States for example various researchers estimate that from 25,000 to 40,000 sites may be considered brownfields. In 2007, it was estimated that there are 64,000 hectares of brownfield land in England, 300,000 hectares in the UK much of which presents severe environmental challenges. Reclamation of brownfields has become a major policy driver in developed countries and there is new urgency among several stakeholders in bringing such lands to useful uses (Dixon et al., 2007).

The definition of post-mine brownfields adopted by this study is abandoned, underutilized landscapes that are degraded, distressed and ruined as a result of mining/quarrying for resources such as stones and sand. Such landscapes that include abandoned mining/quarrying sites are often but not always contaminated and require reclamation, rehabilitation to revitalize and bring them back into beneficial uses (Loures et al., 2015; Ferber et al., 2006; Russ 2000).

The presence and state of post-mine brownfields pose several safety threats in terms of crime and other social evils. They are possible accident sites and generally affect the environment negatively due to poor aesthetics (Buckley & Mason, 2012; Dixon et al., 2007). Mine residue sites have different spatial attributes and therefore different effects on their immediate environments. According to Mert, 2019; Loures et al., 2015; Siebielec, 2012); Dixon et al. (2007) problems of post-mine brownfields on the environment range from economic, social to ecological. These include being safety threats, crime areas, source of air pollution, as well as causing water and soil pollution. They are hence a source of health problems, besides not being aesthetically appealing to residents of neighboring property and the general public. Abandoned sites of quarries, according to Buckley and Mason (2012), attract a host of harmful and unhealthy land uses within the neighborhoods they are found in. These sites are commonly targeted for illegal dumping. Neglected quarry sites often become hang-out sites of local gangs, fuelling various forms of crime. Hazards associated with abandoned post-mine sites include serving as havens or dens for snakes, bats and other dangerous fauna (Buckley & Mason, 2012). Each post-mine site is unique and presents a variety of environmental and safety risks that may vary over time.

Brownfields have several impacts on the urban structure of cities and their locations. Koudela et al. (2004), suggest that brownfields affect the functional utilization of an area negatively as they reduce the intensity of utilization of the area. This then negatively affects the urban economy at

large. The inhabitants and visitors to the city form an impression of failure, social destruction and pessimism due to their neglected appearance within the urban landscapes. This is dangerous for the general social and political atmosphere of the city they are found in. According to Mert (2019) and Siebielec (2012), individual brownfields or areas with high brownfield density can generate environmental, social and economic problems within the neighborhoods and the city at large. The type and scale of the related problem is a basic issue for feasibility of brownfield reclamation. Kryzstofik et al. (2012), posit that brownfields as a component of the urban environment interact negatively in most cases with the other elements within the landscape. Therefore there is need for rational usage of the post-industrial and post-mining areas as new elements of spatial and environmental components by planning for their integration into the planned urban landscapes (Kryzstofik et al., 2012).

According to Koudela et al. (2004) and Siebielec (2012), the general problem of brownfields is the existing or assumed contamination of their soil that is linked to their ground water. Siebielec further states that other environmental problems that might appear are human exposure to contamination, hazardous wastes disposal and, air pollution. Buckley and Mason (2012), state that post-mine sites are commonly targeted for illegal dumping and this has negative impacts on the health of a community. This behavior is a nuisance and lowers the quality of life for the residents, besides creating serious health problems for the community (Buckley and Mason, 2012). According to the U.S Environment Protection Agency (2005), the sources and types of contamination at mine sites vary and can affect soil, groundwater and surface water. Surface water runoff from open pits can carry both toxic and non-toxic materials such as silt to stream and lakes. Seepage from water filled pits can also release contaminants to surface water and ground water. It must however be clarified that not all brownfields sites are contaminated. A study by Martinat et al. (2014) in Brno and Ostarva cities in Czech Republic revealed that the public perception of contamination of brownfields in Brno and Ostrava strongly varied. More than half of the respondents (53%) from Ostrava were disconcerted about potential pollution of soil, water, and the environment in their city, while in Brno worries about possible contamination were showed by merely one quarter of respondents, which left almost three fifths (58%) of respondents perceiving the contamination as being not such a big problem. Significant differences in the opinions of Brno and Ostrava respondents appeared when discussing the perception of urgency in solving the brownfield problems. Those who perceived brownfields as an important problem in Ostrava was almost 40% of the respondents and only 16% in Brno. Those who considered brownfields as a problem of the medium level of urgency were described by 80% of the respondents in Ostrava and 62% in Brno.

In Kenya, several areas have realized continued quarrying for stones, clay, sand and other materials needed in the construction industry. All these have resulted into abandoned post-mine residue areas and more is still expected. Most brownfields take up large portions of land within the core areas of the city that would otherwise be very useful in many ways, especially with the reality of shrinking urban land. Kisumu City has several degraded, distressed landscapes emanating from past mining activities. Past quarrying activities within the city resulted into brownfields that have not undergone any rehabilitation. These sites have since been fully engulfed into the expanding residential neighborhoods thereby posing several problems. Meanwhile, peri-urban quarrying for

building materials like murram needed for ongoing construction is steadily creating the potential brownfields of tomorrow. At the time of the study, information regarding the types of brownfields in Kisumu City, their spatial characteristics, effects on the environment and the best land-use options for reuse through reclamation is not known. According to Loures and Vaz (2016) people's perception towards different brownfield typologies is still understudied and the benefit of the different brownfield types is still poorly addressed. This limits accomplishment of sustainable and resilient development of these distressed, underutilized landscapes (Loures & Vaz, 2016).

This study sought to assess the community perception regarding the effects of the four post-mine sites on the physical environment within their neighborhoods. This was in terms of air pollution, dumping of wastes and possible contamination within them. This study postulates that understanding the effects of the post-mine brownfields is an important step in planning for their rehabilitation in an attempt to integrate them into the planned urban landscape. This is supported by Kryzstofik et al. (2020) who posit that making decisions on spatial development are particularly visible in large cities especially with regard to post-mining areas with focus being on their rehabilitation. As such, the current study intended to assess the community perception of post-mine brownfield's effects on the physical environment in Kisumu, Kenya.

## METHODOLOGY

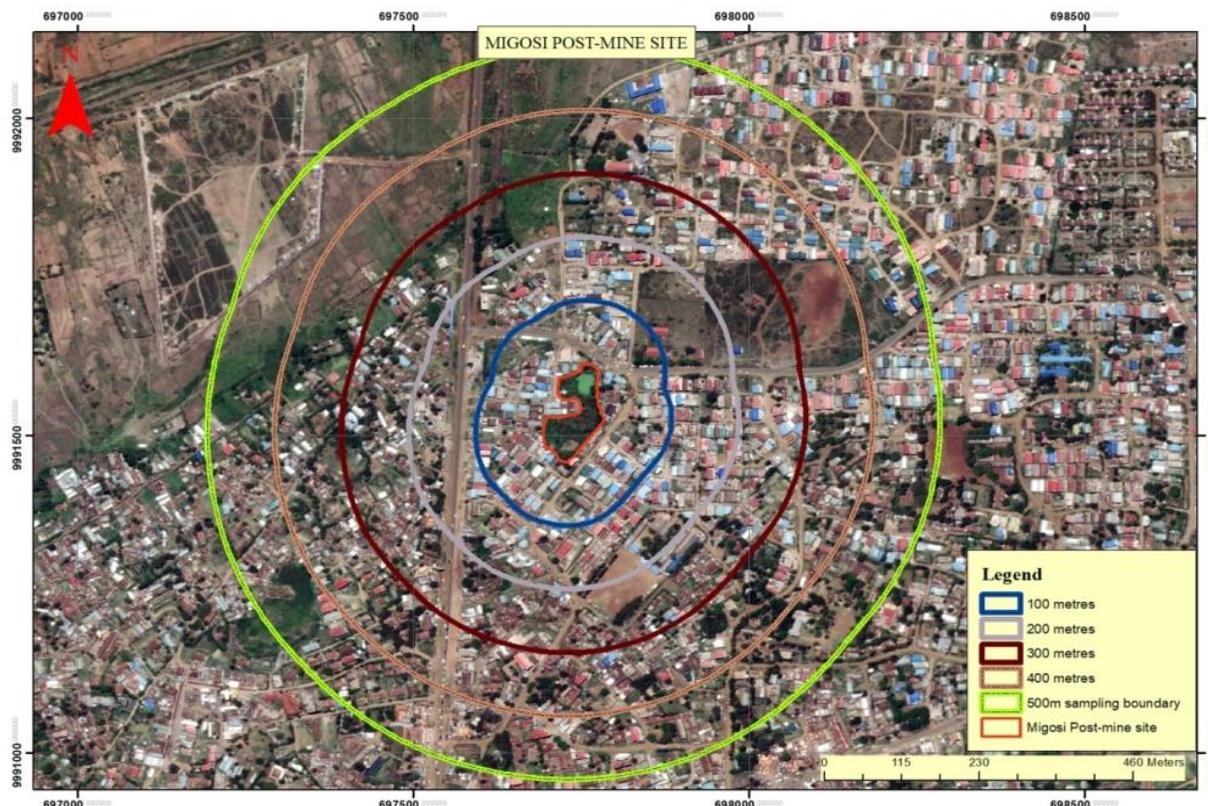
The cross sectional research approach was used to study the post-mine brownfields in terms of their effects on the physical environment. Reconnaissance study was conducted between 2016 and 2017 to identify and locate the post-mine brownfields within the study area of Migosi, Nyawita, Wathorego and Kanyawegi sub-locations.

All the four brownfields under study were identified and selected for study using purposive sampling method due to their large sizes. Each brownfield became a sample site due the fact that they were existing sites of former stone mining areas and that they no longer had mining activities ongoing. Other studies on brownfields have defined a brownfield neighborhood as a 500 meter (0.3 mile) circular radius around a brownfield (Pearsall, 2010; Fisher (2011). Essoka (2010), considered a slightly larger radius of 0.5 mile to allow for more general understanding of socio-economic character of areas adjacent to brownfields. This study was based on households that are living within the 500 metres from the boundary of the brownfield within each of the four sub-locations. According to KNBS (2009), the four sub locations where the four post mine sites are found have a total of 13,127 households. A total of 3300 households constituting a quarter number for all the households within the four sites was used to calculate the total sample size for all the four sites. Sample size calculation was according to Mugenda & Mugenda (2013), for population less than 10,000.

Selecting the households for each brownfield site was based on the sampling frame above with a total of 96 households for all the four sites. The number of households that constituted the sample for each sub location was therefore Migosi 35 households, Nyawita 30, Wathorego 21 and Kanyawegi 10 households Random sampling was used to collect data from the households from

the boundary of each site and in the subsequent radii within the 500 metres boundary. Five concentric circles were drawn in GIS were used to approximate the various radius for data collection around each site. Data was collected from the respondents within each diameter of the concentric rings around each site with each first household being selected randomly and others within the ring picked randomly at various ends all-round the diameter. Proportional stratified sampling technique was used to calculate the number of households to form the sub samples to be interviewed within each of the four sub locations of the study area. Respondents within the various radii were distributed equally. All respondents were picked and included to form the sample size where the household members were willing to participate in the study. Data collection was limited to the various boundaries of each sub location even in cases where the 500 metres radius overlapped into the other neighboring sub location like in the case of Migosi and Nyawita.

Three approaches were used to collect primary data i.e. questionnaire, observation guide and photography and lastly interview schedule for key informants. The respondents were asked their perception on various effects of the post-mine sites within their neighborhoods. Structured questionnaires which consisted of open and close ended questions were used during the data collection process. The questionnaires were administered by the researcher and involved first identifying himself then clarifying the purpose of the study. On site observation was carried at random times of the day for each of the four sites under study. Direct observation involved checking on dumping of wastes. Observation and digital photography helped the researcher to cross check some of the responses from the respondents done through questionnaire. The reconnaissance was carried out by interviewing the area sub-chiefs who are well versed with the location, number and landowners of the brownfields within their areas of jurisdiction.



*Figure 2: Satellite aerial image showing sampling radius intervals and the 500 metres sampling boundary around the Migosi post-mine site*

Source: Satellite aerial image (2018)

In terms of data analysis, both quantitative and qualitative data analysis procedures were used to analyze the collected data. Quantitative data was analyzed using descriptive statistics including percentages. Analyzed data was presented using texts, tables and figures. Key informants included quarry land owners, director of city planning, director of environment at County Government of Kisumu, senior officer at Kisumu Urban Project, Physical planner at Ministry of Lands, Director of National Environment Management Authority (NEMA) Kisumu County, Mines and explosives officer at Ministry of Mining and a private practicing planner. The data from the key informants was collected through various interview schedules that consisted of open ended questions. Qualitative data was then categorized, transcribed and presented based on the study major thematic areas.

## RESULTS

### Demographic Characteristics of the Respondents

Respondents within the four sub-locations of the study area comprised 41% female and 59% male.

The age distribution of the respondents showed that 46% were aged between years 18 and 30, 30% aged 31 to 40years, 15% were aged between 41 and 55while 9% were aged over 55years. Most respondents therefore were between ages 18 and 30. The age distribution is skewed to older age groups implying that most of the participants were mature persons. They were therefore, expected to respond adequately to the study questions that were about the effects of the post-mine brownfields within their neighborhoods at the time of the study.

Marital status of the respondents was that 64% were married 34% single.

Educational attainment of the respondents indicated that 22% had attained primary education, 43% secondary education and 35% had tertiary education and above. The implication of these findings to the study is that 78% of the respondents were educated beyond primary school, hence expected to understand and objectively respond to questions regarding the post-mine brownfields within their neighborhoods.

How long the respondents had lived within the area of study and the brownfield was also analyzed. Those who had stayed for less than two years constituted 14%, two to five years of stay was 33% while the majority at 53% had stayed for more than five years. The length of residence results indicates that majority of the respondents had lived in their various post-mine neighborhoods for a period that would ensure they were aware of the existence of the brownfields and their effects on the neighborhood environment.

### Public Perception of Effects of the Post-Mine Brownfields on the Environment

Effects of the post-mine brownfields were analyzed in terms of the effects on the physical environment within the neighborhoods where they are found. Each brownfield has its different effects on its environment and each was analyzed independently. The effects were studied and analyzed in terms of dumping of wastes, air pollution and possible contamination from past activities such as previous blasting or dumping of wastes. The results are summarized in Table 1 below.

Table 1

*Perceived effects of the post-mine brownfields on physical environment*

Effect	Nyawita post-mine site		Migosi post-mine site		Wathorego post-mine site		Kanyawegi post-mine site	
	Agreed	Disagreed	Agreed	Disagreed	Agreed	Disagreed	Agreed	Disagreed
Dumping of wastes	36%	64%	29%	71%	29%	71%	0%	100%
Air pollution	90%	10%	81%	19%	81%	19%	80%	20%
Possible contamination (Blasting with chemicals or dumping of wastes.	90%	8%	74%	23%	70%	10%	90%	5%

### Public Perception on Dumping of Wastes

Migosi brownfield is a site for unofficial and illegal dumping of wastes and forty three percent of the respondents used it as a dumping ground for their wastes due to nearness/proximity to the brownfield while 55% exploited its abandoned nature to use it for dumping of their household wastes. From Table 1 above, two percent used it for dumping owing to the expensive charges by the waste collecting companies. Those respondents who use it as a dumping ground have used it for varying periods. Those who have dumped for less than two years constituted 14% of the respondents, 50% had dumped for 2-5 years while 36% had used it for dumping for over 5 years. The risk of falling into the brownfield was the reason why 58% did not use it for dumping of wastes, 37% did not use it for dumping due to the far distance from their residence to the abandoned quarry. Having a dumping area within some residence made 5% of the respondents not use it as a dumping ground for their domestic wastes. Dumping of the wastes is carried out by several households and that 81% of the respondents were aware of dumping of the wastes by other households while 19% were not aware of dumping of the wastes by other households. Presence of street urchins during on site observation showed that they came to ravage through the dumped wastes for any valuable items.

According to a middle aged resident and a respondent, Nyawita post-mine in its abandoned state suffered from dumping of wastes that were generated from the nearby Nyawita Maternity & Nursing Home Hospital until it ceased its operations. Twenty percent of the respondents used the post-mine brownfield as a dumping ground for their wastes due to nearness/proximity to the brownfield while 60% exploited its abandoned nature to use it for dumping of their household wastes. Fifteen percent cited both the proximity and abandoned nature for their dumping. Five

percent used the post-mine for dumping to lack of alternative dumping area within their residence. Those respondents who use it as a dumping ground have used it for varying periods. Those who have dumped for less than two years constituted 10% of the respondents, 25% had dumped for 2-5 years while 65% had used it for dumping for over 5 years. The risk of falling into the brownfield was the reason why 37% did not use it for dumping of wastes, 59% did not use it for dumping due to the far distance from their residence to the abandoned quarry. Having a dumping area within some residence and the need for responsible waste disposal made 4% of the respondents not use it as a dumping ground for their domestic wastes. Dumping of the wastes is carried by several households and other sources and that 92% of the respondents were aware of dumping of the wastes by other households while 8% were not aware of dumping of the wastes by other households.

On-site observation at Nyawita showed that by products of alcohol brewing by the brewers within the neighborhood were dumped at the post-mine from time to time and this was a source of air pollution within the waterlogged area next to the entry point. From the field observation carried out, dumping of various wastes within the brownfield occurred at different points within the brownfield. Various points next to the residential houses on the post-mine boundaries showed signs of continued dumping. Nyawita site is the most affected of the four sites due to dumping of wastes that is carried out at different ends.

Kanyawegi post-mine brownfield showed no signs of dumping from the on-site observation and site analysis that was done during reconnaissance and during data collection. The risk of falling into the brownfield was the reason why 40% did not use it for dumping of wastes, 47% did not use it for dumping due to the far distance from their residence to the abandoned quarry, while 13% considered dumping it the post-mine as being environmentally unfriendly and hence did not engage into dumping within the abandoned quarry. Ninety percent the respondents were not aware of dumping of the wastes by other households while 10% were not aware of dumping of the wastes by other households. Kanyawegi post mine site was the cleanest of the four sites under study due to no dumping of wastes by the households around it. Wathorego post-mine brownfield was affected by minimal dumping of wastes from the households. Dumping only occurred within one of the shallow areas that was next to a graded access road that was on the quarry boundary. Forty three of the respondents used the post-mine brownfield as a dumping ground for their wastes due to nearness/proximity to the brownfield while 57% exploited its abandoned nature to use it for dumping of their household wastes. Those respondents who use it as a dumping ground have used it for varying periods. Those who have dumped for less than two years constituted 14% of the respondents, 50% had dumped for 2-5 years while 36% had used it for dumping for over 5 years. The risk of falling into the brownfield was the reason why 58% did not use it for dumping of wastes, 37% did not use it for dumping due to the far distance from their residence to the abandoned quarry while 5% did not use it for dumping because of having a dumping area within their residence. Dumping of the wastes was carried by several households and other sources and that 71% of the respondents were aware of dumping of the wastes by other households while 29% were not aware of dumping of the wastes by other households. According to the Director of Environment at Kisumu County Government and the Director of National Environmental Management Authority many abandoned quarries within the County are targeted for illegal

dumping of various wastes thereby affecting their aesthetic value and affecting the surrounding areas at large.

### **Public Perception on Air Pollution**

At Migosi post-mine site, dumping of various wastes within the stagnant waters of the brownfield occurred at different points within the brownfield. Dumping of the various wastes is the reason for air pollution by 46% of the respondents while 54% associated the water logging within the entire abandoned quarry to the air pollution as indicated in Table 1 above. The respondents who did not associate the brownfield with air pollution cited minimal dumping at 71% and minimal water logging at 29%. Dumping of the various wastes at Nyawita post-mine is the reason for air pollution by 67% of the respondents while 20% associated the water logging within the entire abandoned quarry to the air pollution and 13% associated both dumping of wastes by households and the water logging to the air pollution. The respondents who did not associate the brownfield with air pollution cited minimal dumping at 80% and minimal water logging at 20%.

At Kanyawegi, One hundred percent of the respondents associated the water logging within the abandoned quarry to the air pollution while at Wathorego, dumping of wastes is the reason for air pollution by 46% of the respondents while 54% associated the water logging within the abandoned quarry to the air pollution. The respondents who did not associate the brownfield with air pollution cited minimal dumping at 71% and minimal water logging at 29%.

### **Public Perception on Possible Contamination**

The respondents in the four post-mine brownfield neighborhoods were asked if they felt that the sites had possible contamination. From Table 1 above, forty eight percent of respondents at Migosi associated previous activities like blasting with chemicals to the possible contamination, 17% associated the past and present dumping of various wastes from different sources to the possible contamination while 35% associated both previous activities and dumping of wastes to the possible contamination within the post-mine brownfield. At Nyawita, ten percent associated previous activities like blasting with chemicals to the possible contamination, 60% associated the past and present dumping of various wastes from different sources to the possible contamination while 30% associated both previous activities and dumping of wastes to the possible contamination within the post-mine brownfield.

One hundred percent of respondents at Kanyawegi associated previous activities like blasting with chemicals to the possible contamination while at Wathorego forty eight percent associated previous activities like blasting with chemicals to the possible contamination while 17% associated the past and present dumping of various wastes from different sources to the possible contamination while 35% associated both previous activities and dumping of wastes to the possible contamination within the post-mine brownfield.

## DISCUSSION

The study analyzed the effects on physical environment in terms of dumping of wastes, air pollution, and possible contamination from wastes or past quarrying activities. At the time of the study, dumping of wastes was evident from on-site observation in all the sites except at Kanyawegi site. U.S Environment Protection Agency (2005) refers to open dumping or “midnight dumping” as the illegal disposal of wastes and this is common at abandoned mine sites. This is usually done to avoid costs or inconvenience of legal dumping. Disposal of wastes within abandoned post-mines can cause additional contamination.

According to Mert (2019) and U.S Environment Protection Agency (2005) wastes associated with operations within the mine that may include machine maintenance, vehicle repair or other activities in which solvents, petroleum, lubricants or other industrial chemicals may have been used is a source of contamination. According to the senior inspector of explosives at the mines and geology department of the Ministry of Mining the chemicals and the explosives used during blasting while quarrying is a major source of contamination within the sites as the remains may be found within the rock fractures of the quarry walls and ground.

Continued presence of post-mine brownfields without planning for their reuse into beneficial land uses through rehabilitation means the problems they pose will continue to be felt within their localities. If the present state is not addressed, then illegal dumping, air pollution and possible contamination that impact negatively on the environment will continue to be felt within the neighborhoods that host the abandoned brownfields. The presence of post-mine brownfields should thus be addressed through rehabilitation to eliminate their negative effects so as to achieve social acceptance, environmental sensitivity, and economic gain. If not done, environmental stigma associated with these sites continues and the urban landscape in general is affected.

The study adds to the body of knowledge by adding information regarding post-mine brownfields in Kisumu City that at the time of the study were not existing. The findings bring to the limelight the negative issues regarding post-mine brownfields that need to be identified and planned for in the wake of spreading urban developments in their locations. The planning is vital in integrating them into the urban landscape through rehabilitation of preferred land uses through suggested compatible reuse options.

## CONCLUSIONS

The study established that each brownfield has unique spatial attributes that contributed to the negative effects on the physical environment. All the negative spatial attributes like water logging, deep depths, and untamed vegetation for the four post-mine sites should be addressed to convert them into positive attributes that are beneficial for the preferred reuse options when planning for rehabilitation. Negative effects on the physical environment like dumping should be addressed during planning for rehabilitation by providing alternative ways, places for dealing with the waste management that is currently done within the post-mine sites. Negative effects on the physical environment like dumping that is carried out within these post-mine sites should be stopped.

Planning for the reuse options should consider providing for alternative ways for managing the wastes generated by the households that use them for illegal dumping. Alternative dumping will ensure that the current problems associated with the dumping like foul smells, negative visual quality and resultant air pollution are avoided.

Recommendations were drawn concerning brownfields in regard to their effects on the physical environment within the neighborhoods. Water logging that was prevalent in all of them should be addressed by planning for proper storm water management within and around in order to reverse and eliminate the current problems associated with this negative attribute. There is need for the regional authorities like County Government of Kisumu to have an elaborate database of the various post-mine brownfields within their jurisdiction to aid in planning of the rehabilitation process.

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