# Waste Atlas

## The World's 50 Biggest Dumpsites

2014 Report

Powered by D-WASTE
waste management for everyone

## Collective Work

For the very first time, the World's 50 biggest active dumpsites are profiled in this 2nd Annual Report of Waste Atlas. Data on important dumpsites are collected and visualised in a unified way, supported by a brief statistical analysis. These dumpsites could be associated with important negative socio-economic and environmental impacts, highlighting the importance of global cooperation for elimination of uncontrolled disposal sites.

ISWA International Solid Waste Association | WIERT | SWEEPNET | UNIVERSITY OF LEEDS | SWAPI

## STEERING COMMITTEE

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| **Antonis Mavropoulos** | - CEO of D-waste and Project Director |
| **Hermann Koller** | - Managing Director of ISWA |
| **Markus Luecke** | - GIZ, SWEEP-Net Teamleader |
| **Surendra Shrestha** | - Director of International Environmental Technology Center, UNEP |
| **Masuro Tanaka** | - SWAPI Coordinator, Tokyo University |
| **Nickolas J. Themelis** | - Professor of Chemical Metallurgy, Department of Earth and Environmental Engineering, Columbia University, US |

## SCIENTIFIC COMMITTEE

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| **Jose Fernando Juca** | - Professor at UFPE, Recife Area, Brazil |
| **Stratos Kalogirou** | - President of WTERT Greece<br>- Member of the Board in WTERT/USA in Earth Engineering Center of Columbia University |
| **Agamuthu Pariatamby** | - Editor-in-Chief of WM&R, University of Malaya, Kuala Lumpur, Malaysia |
| **Mario Russo** | - Coordinator Professor at Polytechnic Institute of Viana do Castelo, Portugal |
| **Costas Velis** | - Head of Waste Atlas Scientific Committee<br>- Lecturer in Resource Efficiency Systems, School of Civil Engineering, University of Leeds |
| **Goran Vujic** | - Assistant Professor at the University of Novi Sad, Serbia |

## WASTE ATLAS TEAM

Waste Atlas has been developed through coordinated efforts and contributions by almost a thousand people. However, most of the work regarding the web interface and the data acquisition has been done by the permanent Waste Atlas Team, namely:

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| **Alexandros Mavropoulos** | - D-Waste Expert |
| **Antonis Mavropoulos** | - D-Waste Founder & CEO |
| **Ilianna Koukosia** | - GIS Expert |
| **Maria Tsakona** | - D-Waste Product Manager |
| **Niki Mavropoulou** | - Waste Atlas Project Manager |
| **Nikos Rigas** | - Graphic Designer |
| **Theodore Andreadakis** | - Layout Editor |

# CONTRIBUTORS

We would like to thank all the contributors for the data they provided. We would like to thank especially the following people for their excellent contributions: Ranjith Annepu (India), Timothy Byrne (United Kingdom), Marco Caniato (Italy), Magda Correal (Colombia), Natālija Cudečka-Puriņa (Latvia), Makoto Fujita (Japan), Vujic Goran (Serbia),Alberto Huiman (Peru) Mansoor A. H. Imam (Pakistan), Edith Iriruaga (Nigeria), Joy Jadam (Lebanon), Nathalia Lima (Brazil), Ana Loureiro (Portugal), Nikola Maodus (Serbia), Liubov Melnikova (Russia), Ralf Mueller (Germany), Juan Antonio Munizaga (Chile), Iris Odenthal (Germany), Margaret Oshodi (Nigeria), Michiko Ota (Japan), Peru Waste Innovation S.A.C (Peru), Venkata Reddy (India), Eva Ridick (Mongolia), Ricardo Rollandi (Argentina), Atilio Savino (Argentina), Carlos RV Silva Filho (Brazil), Dini Trisyanti (Indonesia), Nickolas Themelis (USA), Tshephang Tumoyagae (Botswana), Jenny Westin (Sweden), Filipa Vaz (Portugal), Christos Venetis (Greece), Claudio Vieira (Brazil).

A special thanks to Dr. Costas Velis and Pranay Kosambia from the University of Leeds for the statistical analysis, provided for Waste Atlas Report 2014.

Website: http://www.d-waste.com
E-mail: info@d-waste.com
Graphic design and layout: D-Waste Creative Department

## WASTE ATLAS PARTNERSHIP

ISWA International Solid Waste Association
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D-WASTE waste management for everyone

# LEGAL NOTICE

# PREFACE

This is the second Waste Atlas Report. After one year, 800 users of the Waste Atlas mobile app, more than 1,000 contributors, 5,500 downloads and 10,000 unique users of Waste Atlas, we are happy to create a second emblematic report dedicated to the 50 biggest active dumpsites of the world.

It was a clear result of the first Waste Atlas Report. More than half of the world's population is using dumpsites for waste disposal. Then the next questions come naturally. Which are the most risky dumpsites? Where are they located and what are their health and environmental impacts? How many people are affected? It seems unbelievable, but up to now there was no effort to list the biggest (and most possibly the riskiest) dumpsites of the world, despite the fact that all the international stakeholders prioritise the closure of dumpsites as a top priority for health and environmental protection.

So, the Waste Atlas Partnership decided to respond to this challenge and this report is the first one that lists and profiles the 50 biggest (at least from what we know) active dumpsites of the world. Maybe there are some big dumpsites, which are not included, because we did not acquire a sound data set for them. Maybe there are even bigger ones for which we have no idea. But in any case, this list is an important first step and we hope that, with the contributions of several institutions, it will be expanded to include the 100 and then the 1,000 biggest dumpsites of the world, with more and better data sets available.

It is clear that the 50 biggest active dumpsites should not be considered, simply, as local problems. They affect the daily lives of 64 million people, a figure similar to the population of France. Their total waste volume is 0.6-0.8 $km^3$, almost 200-300 times the volume of the Great Pyramid of Giza. Most of them are located in very poor countries, with no financial and human resources available to implement a sound waste management system. I really believe that the closure and rehabilitation of those dumpsites (and the development of sound waste management systems) must be considered as a global challenge and not a local one. And I am sure that the list provided by this report will serve as a first step towards the understanding of this global challenge.

This list would never be realized without the combination of crowdsourcing and scientific research. We are really thankful to the hundreds of contributors of Waste Atlas and the most important of them are listed at the beginning of the report. I believe that the time has come to create a vibrating community of contributors, users and followers of Waste Atlas – this is the only way to make the project sustainable and to increase its scientific value. Waste Atlas is an evidence for the power of crowdsourcing, when it is combined with scientific analysis.

We are also thankful to the University of Leeds for its scientific support that upgraded data collection and acquisition. As part of Waste Atlas general policy, we are ready to involve more universities, students and academics to Waste Atlas, with a variety of ways. Waste Atlas has a huge data set and the more people involved in data sets elaboration and analysis, the better the results achieved.

Last, but not least, I would like to ask everyone to provide us feedback for this report but also for the Waste Atlas website and apps. This feedback is of vital importance as we are in a phase of redesigning the interfaces and the databases, in order to make them more attractive and interactive for the users. Please let us know what you need more, what you like or no, give us more ideas that you would like to see implemented. Please propose ways for more and better involvement of the users, for better user experience. In other words, let's work together to make Waste Atlas a tool for a massive scientific collaboration regarding the global waste challenges. Both the first and the second report of Waste Atlas indicate that we can do it!

**Antonis Mavropoulos**
**D-Waste Founder & CEO**

# KEY MESSAGES

## HEAD OF WASTE ATLAS SCIENTIFIC COMMITTEE

Where the most severe threats to human health and natural environment, local and planetary, associated with unsound management of solid wastes occur around the world today? We may lack the evidence to authoritatively answer this landmark question. Yet, dumpsites can be safely linked to very high levels of risks and potential harm. There, simultaneous inhaling of fumes from burning plastics, contamination of aquifers, and release of substantial qualities of greenhouse gasses takes place. In that sense, the invention of the sanitary (and then engineered and controlled) landfill was one of the single most important steps in minimising the adverse effects of poor solid waste disposal methods. Some 100 years after starting building engineered landfills in Europe and the US, considerable part of the world's waste is still disposed of openly on the ground, wetlands, rivers and seas. Therefore, there is an urgent need to raise our awareness on this challenge; and hopefully stimulate co-ordinated efforts to rapidly eliminate this threatening disgrace. Hence a name and shame publication here, with the ambition of putting the 50 biggest dumpsites of today's world on the map. So that we cannot anymore say that we did not know.

Gathering the evidence was far from straightforward: scientific and 'grey' non-peer reviewed literature were both scanned for information on dumpsites. Somehow not surprising, the scientific evidence on the topic is limited. What got us further was the data sharing from local experts, to whom we are grateful for their enthusiastic key contribution of otherwise inaccessible or obscure information. This demonstrates the power of the Waste Atlas in mobilising expertise and collecting scientific and lay knowledge on transformative topics of landmark nature, materialised with relatively minimal resources. However, it also demonstrates inevitable limitations and barriers to be overcome in future efforts, such as the obvious gap of relevant information within China.

University of Leeds leading the scientific advice within the Waste Atlas Partnership, supported this effort by informing the data collection pro-forma, statistically analysing the data collected and reviewing the literature on implications of dumpsites on human health. Analysis revealed key patterns, documented here for the very first time, such as the correlation between numbers of people potentially exposed to dumpsites and the size of dumpsites, evident for biggest population agglomerations. And allowed us to create the profile of the average 'monstrous' dumpsite of our times, which we invite you to examine and see how it fits with your own experiences.

There is strong scientific evidence regarding the adverse implications of living and working on dumpsites which affects the informal recyclers / waste pickers who frequent the dumpsites to make a living from our wastes. This worldwide reality vividly demonstrates the residual value in solid wastes, but also should alert us about the unnecessary risks these unprivileged people are exposed to. Some of the biggest risks and effects stem from co-disposal of municipal with hazardous and healthcare wastes: it is high time to move away from such practices, ensuring separate management routes. Considerable urban populations live close to dumpsites. Whereas concrete evidence on adverse effects is still in its infancy, limited by the inherent difficulties of epidemiological studies, the mere fact of this proximity should suffice to alert us.

Waste Altas once again shares a unique dataset on solid waste management: it is about the potentially maximum harm to humans and the environment occurring today around us because of poor management of solid wastes. Action to alleviate this will require demanding efforts of international collaboration and substantial funds. But now, having revealed the tip of the dumpsite iceberg, we know.

**Costas Velis**
**Lecturer in Resource Efficiency Systems, School of Civil Engineering, University of Leeds**

## STEERING COMMITTEE

**Hermann Koller, Managing Director of ISWA:** Despite considerable advancement in waste management practices worldwide, this report sends a crystal clear message that we are still falling far short of the mark in many of the world's cities. This bold and successful effort to quantify the scale and impact of the largest sites of uncontrolled waste disposal, comes at a time when high level attention to address the need for appropriate waste management needs to be reinforced. Growing quantities and complexity of wastes being generated, together with a lack of funds and institutional capacity, means the issue is far larger than the resources available to many cities. A concerted effort by all actors involved in waste management is needed to bring to an end the practice of uncontrolled disposal, which as this report underlines, leads to tremendously detrimental health and environmental impacts.

**Nickolas J. Themelis, Professor at Columbia University and founder of Global WTERT Council:** The Global WTERT Council is proud to be a part of the Waste Atlas Project. The information that has been compiled will help the developing countries in Africa and Asia to advance sustainable waste management and phase out existing illegal dumpsites and non-regulated landfills. It will also encourage the society, starting from the simple people to policymakers to reuse, recycle, compost, and recover energy from post-recycling wastes worldwide. Learning from Waste Atlas what other countries are doing will also help people to avoid bad syndromes like NIMBY and governments to include waste management in their top priority as it has been done in the past, for potable water & electricity.

In particular, we would like to congratulate Antonis Mavropoulos and his team for their vision and execution of this project.

**Markus Luecke, GIZ/SWEEP-Net Team Leader (http://www.sweep-net.org/):** Waste Atlas is an excellent and very useful application for global and regional waste management benchmarking and provides a global platform where countries can present their state and pace of development in this important sector. SWEEP-Net as the regional network for the exchange of expertise and experience in the Middle East and North Africa (MENA) is proud to be part of it. SWEEP-Net in its ambition to support its partner countries in further developing an integrated solid waste and resource management will continue in its efforts in contributing with all possible means.

**Surendra Shrestha, Director of International Environmental Technology Center, UNEP:** UNEP supports initiatives associated with moving away from open dumping to practices where the waste is better contained and covered, utilized as a resource for raw material and for energy, and environmental impacts from waste disposal are progressively reduced. Identifying the location, characteristics and impacts of the world's biggest dumpsites raises awareness towards collective solutions that will progressively reduce open dumping.

The 2014 Waste Atlas Report highlights in a very illustrative way the key socio-economic and environmental issues of big active dumpsites around the world. It is a unique work which gives new urgency to establishing ambitious, formal and regulated processes for collecting and managing waste in the developing world which is currently seeing an exponential growth in the generation of waste.

# SCIENTIFIC COMMITTEE

**Mário Russo, Coordinator Professor at Polytechnic Institute of Viana do Castelo:** This second report of Waste Atlas is a document of great value. Graphically it is very evocative and educational, easy to read and very illustrative. It provides important information on the main characteristics of the world's largest dumpsites and the risks that they can cause. The way the information is presented; in templates with buffer zones, photos and distances from the closest natural elements, is very ingenious. Furthermore, the descriptive text at the bottom of each template, summarising key data of the presented dumpsite, draws attention on the serious risks that populations and the environment are subject to.

It is also noteworthy to mention that the case studies given at the end of the report are very well summarised examples of the most common problems related to the operation of dumpsites and can become keystone to raise awareness. In addition they are good examples of how other known cases studies can be incorporated in Waste Atlas.

This work is of great significance because it draws attention particularly to policy makers in order to put the issue of unsound disposal on their agenda of priorities for action. Also, it unveils a problem that concerns all of us and is a valuable tool for international bodies with responsibilities on the Environment and Public Health Area, NGOs, international donors and researchers to act as pressure groups in order the correspondent authorities to solve this problem.

Finally, I would like to address my compliments to Antonis and his team for this magnificent work. It is a valuable contribution in favor of the poorest people on our planet and of safeguarding the environment and natural resources. Congratulations Antonis and many thanks.

**Goran Vujic, Associate Professor at the University of Novi Sad:** One of the greatest challenges for one who work on the improvement of Solid Waste Management (SWM), in developing countries is to deal with unsound waste disposal practices and eliminate open active dumpsites. This is a rather difficult task since organizational, political and financial issues are a fundamental challenge in improving waste management performance in many countries, especially in the developing world. That is the main reason why the solving of the waste problem takes the last place in a long list of other problems. The technology for secure sanitary landfills is well established in many developing countries but weak regulation and lack of finance often means that many governments take the cheaper option of dumping.

In this sense this year's Waste Atlas report is dedicated to the urgent global issue of unsound waste disposal. Aim of the report is to map the biggest waste disposal sites and highlight their significant environmental and health impacts. The importance of this excellent collective work is that for the first time crucial information, such as waste in place, number of waste pickers found on dumpsites, and affected population and natural resources around dumpsites, are provided for a list of the biggest global disposal sites.

It is important that all of us, students, professors, engineers, decision makers and authorities, involved in SWM to enhance such efforts and contribute as much as possible. Especially, the academic society has a major role to play towards this direction and enhance the realization of relative studies.

# SCIENTIFIC COMMITTEE

**Agamuthu Pariatamby, Editor-in-Chief of WM&R, University of Malaya:** The Waste - Atlas is a very innovative and significant approach towards cataloging dumpsites. The report not only highlights the most important dump sites it also provides a concise analysis of the problems associated with them. The case studies provided at the end of the document also provide an extensive knowledge regarding the problems faced by the people living in and around the dumpsites. This document will also make the local authorities aware of the different problems related to human health and environmental impacts of the dumpsites to the area. As a solid waste professional we always aim towards preventing growth of any new dumpsites, as well as trying ways to close down the existing ones due to the various adverse socio-economic and environmental impacts associated with dumping grounds. Identifying and locating dumpsites is an integral part in being able to understand the reason behind the growth of dumpsite in the region and the ways to stop its growth and finally taking steps towards its closure. Researchers working in the field of waste management would also be greatly benefited by this atlas as it provides a vivid picture of dumpsites across the world and the problems associated with them. In short it is a great document and would prove to be very helpful to a wide spectrum of professionals across the world.

# CONTENTS

# INTRODUCTION

The 1st Waste Atlas Report estimated that almost half of the world's population lacks access to even the most elementary waste collection and sound disposal services. It has revealed that almost 40% of the waste generated globally is unsoundly disposed of in open dumpsites. Most of these disposal sites can be found in low income and developing countries and are located close to urban areas, posing a major threat to the human health and the environment.

There is a growing concern about the status and the implications of these open dumps. What types of waste and how much of it do they receive? What is their size and exact location? How about waste picking activities on site? What is the number of people potentially affected by the operation of these dumpsites? What are the wider implications for human health and the environment?

If answers like the ones above could be answered, as far as possible quantitatively, the most important dumpsites would be profiled raising global awareness and forming the basis for a more in depth and wider scientific analysis. Therefore, the Waste Atlas Partnership has decided to dedicate this year's annual report on mapping the world's 50 most important dumpsites and addressing the related information challenges.


# AIM OF THE REPORT

Most of dumpsites are located in Africa, Latin America, the Caribbean and Northern Asian countries, namely in areas where more than two third of of the Earth's population lives. According to World Health Organization (WHO), 24% of global burden of diseases could be attributed to the environment[1] and for sure dumpsites have an important contribution.

But speaking generally about dumpsites is not enough. There is a need to draft a baseline by assessing the current situation, the health and environmental problems, the affected populations, the current and future risks associated with dumpsites. There is a need to prioritise interventions based on risk-based approaches and identify the world's most risky dumpsites. And then, there is a need to create tailor - made plans for their closure and rehabilitation. The problem is that all those difficult and demanding tasks are left to local communities and authorities, which in most cases do not have the financial and human resources required to implement them.

The truth is that up to now there are no international, coordinated efforts to catalogue the most risky dumpsites worldwide in order to mobilise international aid for their upgrade, closure and/or rehabilitation. This is why the Waste Atlas partnership decided to make the first list with the most important dumpsites of the world. Because the closure of those dumpsites is much more than a local or a national issue, it is a global challenge for the international community.

This is neither an easy nor a simple task. The absence of relevant data is a key limiting factor. The uncertainties involved are really high. This report attempts to bridge this information gap, collecting and analysing evidence for a list of the biggest currently active dumpsites identified, providing so a first estimate of the amount of waste disposed on them, identifying their exact location, assessing the number of the potentially affected population (waste pickers and inhabitant) and identifying nearby natural resources at risk.

Given the lack of documentation on this topic, identification and data verification for dumpsites is a demanding task. The Waste Atlas Partnership presents now the results of an ongoing work, sharing the profiles of the 50 biggest active dumpsites of the world. The Waste Atlas Partnership hopes that the release of this report will create more global awareness about dumpsites and it will help donors and policy makers to stimulate projects for those dumpsites. The publication of this report will attract new contributions that will expand the catalogue to 100 and then to 1,000 most risky dumpsites. Waste Atlas is here to receive and acquire them, upgrading the crowdsourcing contributions to scientific results.


[1] R. Taylor and A. Allen,'Waste disposal and landfill: Information needs, In: Schmoll, O., Howard, G., Chilton, J., Chorus, I. (eds). Protecting Groundwater for Health: Managing the Quality of Drinking-water Sources, WHO Drinking Water Quality Series Monograph, IWA Publishing, 2006, Available at http://www.who.int/water_sanitation_health/resourcesquality/en/groundwater12.pdf (accessed on 15th July 2014)

# DUMPSITES & THEIR IMPACTS

Dumpsites can be thought of as on-land throwing away areas, insufficiently managed, where solid waste is disposed of in an uncontrolled manner that does not protect the environment. Some of the main characteristics of a dumpsite: waste are dispersed widely, with no coverage or compaction and they remain susceptible to open burning, frequent fires occurring, are exposed to the elements of weather, are a source of disease vectors and frequented by scavenging animals such as birds and dogs. Often, they are not engineered at all, with no leachate management and no landfill gas collection. They are poorly managed, if at all, without any controls on materials accepted or records kept and no security. Informal recyclers (waste pickers) are often found working collecting recyclables without any protection measures or even living within dumpsites, sometimes even scavenging for food leftovers. In this sense, dumpsites pose significant health and environmental threats both to the people involved in the operations and to the wider general public living close by.

Dumpsites have nothing to do with sanitary landfills where waste is disposed of in a specifically designed infrastructure that involves environmental pollution abatement equipment and structural elements, and where operational practices and waste control are carefully implemented.  And while dumpsites have to be closed and rehabilitated in any case, sanitary landfills remain the only viable alternative for waste disposal in most of the developing countries.

Open dumping often takes place close to the urban centers and in some cases residential areas are formed and expanded around dumpsites. The increase of the technically engineered non-biodegradable materials and subsequent waste, along with the rise of population and urbanisation, and the change of lifestyles, have all possibly played significant role in the expansion of already existing dumpsites, and the establishment of new ones, especially in the low income and developing world countries. In particular, the rapid urbanisation rate experienced in the developing countries is directly linked with the creation of new dumpsites, especially in the emerging urban centers. The wider institutional, financial and technical limitations of the authorities and other stakeholders often result in inability to provide even the basic sanitation services, making (illegal) dumping an 'inevitable' reality.

The most common environmental issues for dumpsites relate to surface water, groundwater, and soil contamination from potentially toxic elements ('heavy metals' and metalloids); air pollution from open surface burning of materials, underground fires fueled by landfill gas, and gas leakage; and biodiversity problems as fauna consumes either directly solid waste, or contaminated plants and/or animals and flora contaminated from leakage and waste and affected by the gas emissions. Annex II describes the overall problematic of closing the dumpsites and describes their impacts and the major problems involved.

The most common human health (public and occupational) issues are diseases related to gastrointestinal, dermatological, respiratory, and genetic systems; and several other types of infectious diseases. The nearby dwelling populations face up greater odds to suffer from diarrhoea, headaches, chest pains, irritation of the skin, nose and eyes, typhoid, stomach ulcers. People who work in dumpsites, such as the waste pickers, are more prone to experience these diseases; and the risks exposed to often include in addition accidents from cuts and injuries to fatalities from landslides and trucks. Annex III outlines the major health impacts related to dumpsites.

# THE TOP 50 LIST

## Definition

The perception of what constitutes a dumpsite is not uniform around the world. In many developing countries, and especially in Africa, dumpsites are sometimes called ‘landfills’, although they do not meet the minimum criteria of environmental protection. This misconception was identified early during the preliminary research. As a result, an assessment of each site was conducted, considering their engineered features along with operational practices.

According ISWA’s Key-Issue paper on “Closing of open dumps”, the term “open dump” (or dumpsite) is used to characterise a land disposal site where the indiscriminate deposit of solid waste takes place with either no, or at best very limited measures to control the operation and to protect the surrounding environment. Following this description, disposal sites without liners, without leachate and gas management systems, without anti-flooding measures and sound operations were classified as dumpsites.

## Background & Visualisation

The top 50 list presents in a snapshot the profiles of the 50 biggest active dumpsites around the world according to their size, amount of waste disposed of, number of people potentially influenced and risks posed to the environment and human health. The list includes sites with recent and reliable data, as sourced from the Waste Atlas Partner organisations, academic publications, official and commercial reports and other ‘grey’ literature such as news in the media. Data collection and analysis was conducted following a consistent methodology, which is detailed in Annex I.

Information for each dumpsite is presented in the format of standardised profile templates, which provides its key features: waste in place (tonnes, t), type of waste, size (ha), number of the informal sector on the site, number of the population living in a 10 km radius from the site, and location of nearby natural resources. Distance of nearest settlement (m) and waste concentration, defined as waste weight deposited over area (t/ha), are also provided. The profiles put the dumpsites in geographical context using Google maps, and visualise the related population, and where feasible, the potential environmental and health impacts. Photos taken from the site illustrate the situation on the ground and provide a visual mean of the on-site conditions.

This visualisation approach was followed because it gives a contextual snapshot of both the technical, environmental and social aspects of each dumpsite. The readers are encouraged to use these snapshots to their presentations and papers, as a measure that will stimulate global understanding of the problems related to dumpsites.

## Limitations

The major limitations experienced, during data collection and development of the profiles of the dumpsites, are summarised below:

1. There is inherent difficulty in defining the “biggest” dumpsite and sorting them accordingly. Here, “biggest” was identified according to a set of indicators for the size of the site, the amount of waste disposed annually, the number of the informal sector workers found on site, the residents around and a 10 km radius from the site, the important nearby natural resources, and the risks posed to health and the environment. The methodology followed to create the top 50 list is provided in Annex I.
2. In most cases it was difficult to identify the exact location of the dumpsite. Only after extensive research and help from the contributors, it was possible to locate most of the sites presented here. However, for some dumpsites failure to identify their location led to their exclusion from the top 50 list.
3. Although there is evidence that some of the biggest active dumpsites are located in China, it was impossible to acquire data sets for them, and hence they were excluded from this report.

# HOW TO READ THE TEMPLATES

All the dumpsites are presented with the same template. The template is divided in three zones of information.

**The first zone**, on the top of the template, provides information about the location of the site: Country, City and Site Name. The color of the title differs according to the continent of origin of the dumpsite. Red color refers to Africa, Dark Blue to Europe, Yellow to Asia, Green to Latin America and Light Blue to Central America and the Caribbean.


**On the second zone,** the aerial picture of the dumpsite location, is provided, along with several information. Site position and name of the site, is given in the middle of the picture. 3 buffer zones peripheral to the site are identified with different color at distances 200 m, 500 m and 1,000 m from the site. Blue color corresponds to 200 m buffer zone, while yellow and green are corresponding to 500 m and 1,000 m buffer zones, respectively. In addition, a map scale is provided at the left bottom. On the left top of the picture, a global map with a pin indicating the location of the site and coordinates given by World Geodetic System 84 (WGS 84) are also provided. On the right top, pictures of the site illustrate the current situation in place. In some cases more than one picture is given. On the left bottom, a box provides brief information about the site: waste in place, type of waste, size, waste concentration, informal sector, population within 10 km, distance of nearest settlement and natural resources at risk. Information about their definition and the way they were calculated is available in Annex I. Finally, at the right bottom, an aerial picture of the relative position of natural resources within 10 km buffer zone from the center of the site is presented.

**On the third zone**, a descriptive text of the site is given. Sources are provided in Annex V of the report.

# DUMPSITE PROFILES


## Africa

1. Agbogbloshie
2. Arlington
3. Awotan (Apete)
4. Dandora
5. Doumanzana
6. Eneka
7. Epe
8. Granville Brook (Kissy)
9. Hulene
10. Kibarani
11. Lagoon
12. Lapite
13. Luipaardsvlei
14. Mbeubeuss
15. New England Road
16. Olushosun
17. Pugu Kinyamwezi
18. Solous 2

## Asia

1. Al Akaider
2. Al-Husaineyat
3. Bantar Gebang
4. Bishkek (BADS)
5. Bruhat Bangalore Mahanagara Palike(BBMP) (Mandur)
6. Deir al Balah
7. Deonar
8. Ghazipur
9. Htain Bin
10. Htwei Chaung
11. Jam Chakro (Surjani site)
12. Johr al Deek
13. Mehmood Booti
14. Payatas
15. Sofa (Rafah)
16. Suwung
17. Tibar

## Europe

1. Alushta
2. Vinča

## Latin America

1. Bariloche
2. Cancharani
3. El Milagro
4. Estrutural
5. Jaquira (Haquira)
6. K'ara K'ara
7. Quebrada Honda Ispampa Yura
8. Reque

## Caribbean

1. El Trebol
2. La Chureca
3. La Duquesa
4. Tegucigalpa
5. Trutier

# Africa

# Ghana - Accra - Agbogbloshie


| | |
|---|---|
| Waste in Place (t) | 1,750,000 - 2,500,000 |
| Type of Waste | E-waste |
| Size (ha) | 10.6 |
| Waste Concentration (t/ha) | 165,000 - 235,000 |
| Informal Sector | 10,000 |
| Population within 10 km (inh) | 2,350,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | Odaw River, Korle Lagoon, sea, Achimota Forest Reserve, |

Agbogbloshie is one of the biggest E-waste dumps[1] in Africa, with an average size of 10.6 hectares[2] and annual capacity of 192,000 tonnes[3]. During its 13 years of operation the site has received around 1,750,000 to 2,500,000 tonnes of E-waste[4]. The presence of the informal sector is rather significant. More than 10,000 people process E-waste on the site to recover "precious metals" such as copper, aluminum and iron[5]. It is estimated that 2.3 million people live around the site within a radius of 10 km[2]. Open burning is rather common on the site causing a thick black smoke, that has been related with numerous respiratory and chest problems, chronic nausea and headaches[6] of the informal sector. It has also been reported that 80% of the children leaving on and nearby the site have increased levels of lead in their blood[7]. High levels of toxins have also been discovered in soil and food samples as the toxic chemicals emitted into the ground, water and atmosphere when e-waste are broken down, burned and processed1. The aquatic life of Odaw River (200 m), Korle Lagoon (2 km) and the nearby sea (Gulf of Guinea) (2.5 km)[2] has been substantially disrupted due to high levels of heavy metals and e-waste flotation[8,9].

# South Africa - Port Elizabeth - Arlington


| | |
|---|---|
| Waste in Place (t) | 2,500,000 - 3,600,000 |
| Type of Waste | MSW, Hazardous Waste |
| Size (ha) | 13.2 |
| Waste Concentration (t/ha) | 189,000 - 272,000 |
| Informal Sector | 100 |
| Population within 10 km (inh) | 148,000 |
| Distance of nearest settlement (m) | 1,500 |
| Natural Resources at Risk | NMMU Private Nature Reserve North End Lake, sea |

Arlington waste dumpsite is located in Port Elizabeth, South Africa and has been in operation since 1984[1]. Till now, it has received around 2.5 to 3.6 million tonnes[2] of MSW and Liquid Hazardous waste[3]. The site covers an area of 13.2 ha[2] and is situated 1.5 km from the nearest settlement and nearby the sea (5 km)[2]. At a distance of 9 km from the site there are the NMMU Private Nature Reserve and North End Lake[2]. In the site can be found around 100 waste pickers[4] working.

# Nigeria - Ibadan - Awotan (Apete)


| | |
|---|---|
| Waste in Place (t) | 370,000 - 525,000 |
| Type of Waste | MSW |
| Size (ha) | 14 |
| Waste Concentration (t/ha) | 27,200 - 38,600 |
| Informal Sector | 80 |
| Population within 10 km (inh) | 500,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | Lake Eleyele, IITA Forest Reserve |

Awotan (Apete) Dumpsite is located in Ibadan, the third metropolitan area of Nigeria[1]. It has been active since 1998[2] and receives 36,000 tonnes of MSW[2] annually. At an area of 14 ha, 370,000 to 525,000 tonnes of waste[3] have already been disposed. More than 80 people scavenging for recyclables[4] on the dumpsite, while many dumpsite workers, truck and lorry drivers do the same to complement their monthly salaries[5]. The site is a breeding ground for diseases such as cholera, dysentery and other airborne and skin diseases for the residents of the nearest settlement; only 200 m away from the dumpsite[3]. Groundwater contamination has also been reported at local well's making water unsafe to consume[6]. Nearest natural resources are the Eleyele Lake and ITA Forest Reserve; 2.5 km and 4.5 km respectively[3].

# Kenya - Dandora- Dandora


| | |
|---|---|
| Waste in Place (t) | 19,500,000 - 27,750,000 |
| Type of Waste | MSW, Hazardous Waste |
| Size (ha) | 53 |
| Waste Concentration (t/ha) | 367,000 - 523,000 |
| Informal Sector | 3,000 |
| Population within 10 km (inh) | 3,400,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | Athi River |

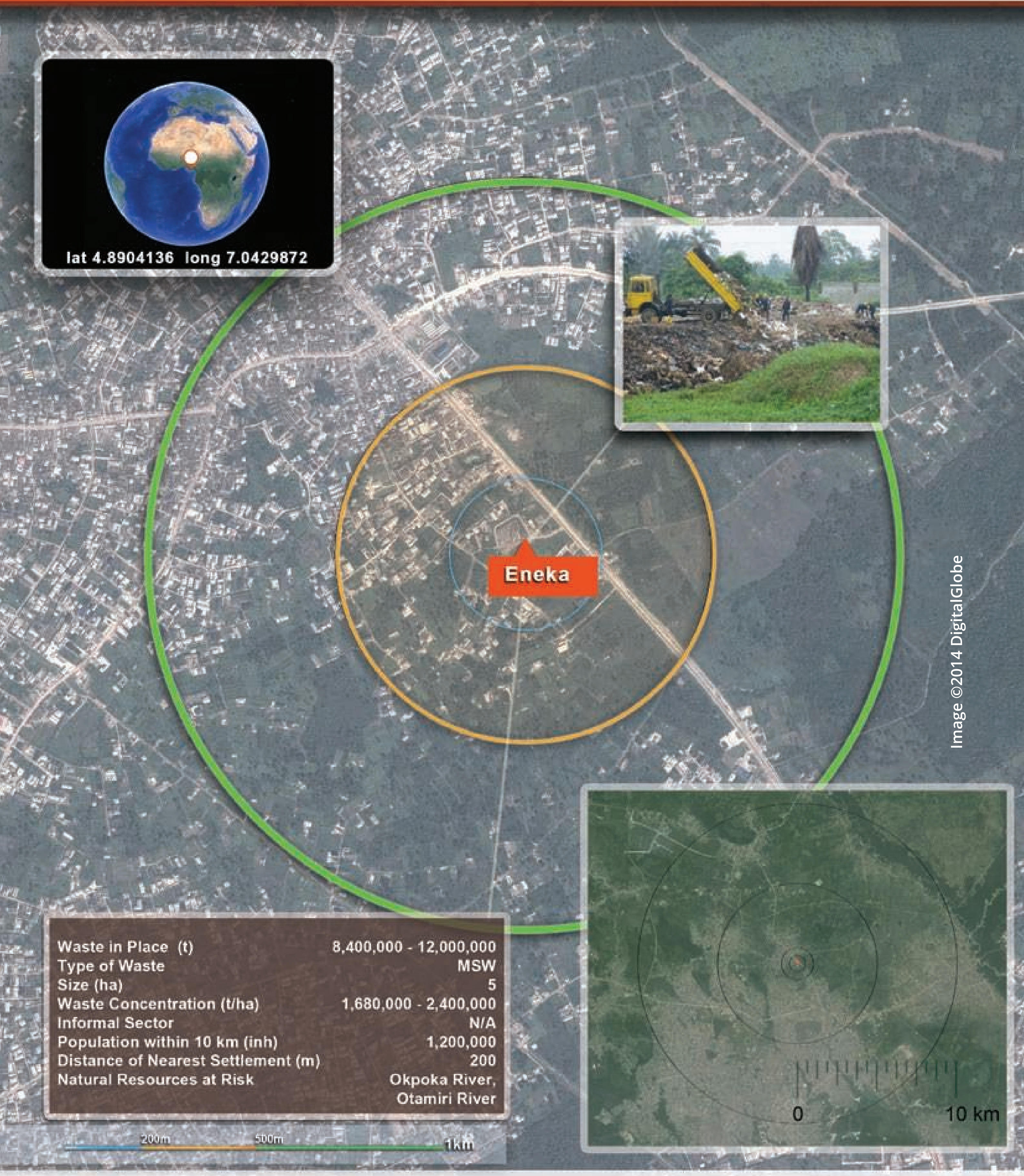
Dandora is Nairobi's principal dumping site[1]. It has a size of 53 ha[2] and receives about 730,000 tonnes[3] (2007) of MSW, Hospital, Agricultural and Industrial waste[4] , annually. It has been estimated that 19,500,000 to 27,750,000 tonnes of waste have been disposed at the site, since its initial operation in 1975[5]. Almost 3,000 waste pickers , men and women are found on the site, on daily basis, seeking for food and sorting out waste such as metals, rubber, glass, plastics, and electronics[7]. Nearby slums have a population of 1,000,000[3] with the nearest in a distance of less than 200 meters[2], while it has been estimated that almost 3.5 million people live within a 10 km radius from the site[3]. Due to the dump close distance from dwellings, numerous health problems related to respiratory, gastrointestinal and dermatological diseases and high blood lead levels[8] have been reported. Cholera, malaria, typhoid, sexual transmitted diseases and HIV/AIDS are also wide spread among the slums population . Furthermore, heavy metals such as lead, mercury and copper and organic pollutants as aldrin, dieldrin and carbonates[4,7] , that escape from the dumpsite of Dandora, are responsibe for water pollution of the adjacent Athi River.

# Mali - Bamako - Doumanzana


| | |
|---|---|
| Waste in Place (t) | 1,250,000 - 1,800,000 |
| Type of Waste | MSW |
| Size (ha) | 10 |
| Waste Concentration (t/ha) | 166,000 - 240,000 |
| Informal Sector | 670 |
| Population within 10 km (inh) | 1,245,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | Niger River |

Doumanzana dumpsite is located in Mali's capital, Bamako, 5 km north of the Niger River[2]. During its 12 years[1] of operation the site has received around 1,250,000 to 1,800,000 tonnes of MSW[2]. The dumpsite, which lies on an old quarry[3], covers an area of 10 ha[2]. In 2007, it received 147,000 tonnes of waste[3] . Currently, 700 people[4,5] search daily for plastic, metal scraps, cans, bottles etc.[5] on the dumpsite while sporadic fires and emissions of site gases[6] burden the surrounding atmospheric.Around 1.2 million people living within a 10 km radius[2] are potentially influenced from its operation.

# Nigeria - Port Harcourt - Eneka




| | |
|---|---|
| Waste in Place (t) | 8,400,000 - 12,000,000 |
| Type of Waste | MSW |
| Size (ha) | 5 |
| Waste Concentration (t/ha) | 1,680,000 - 2,400,000 |
| Informal Sector | N/A |
| Population within 10 km (inh) | 1,200,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | Okpoka River, Otamiri River |

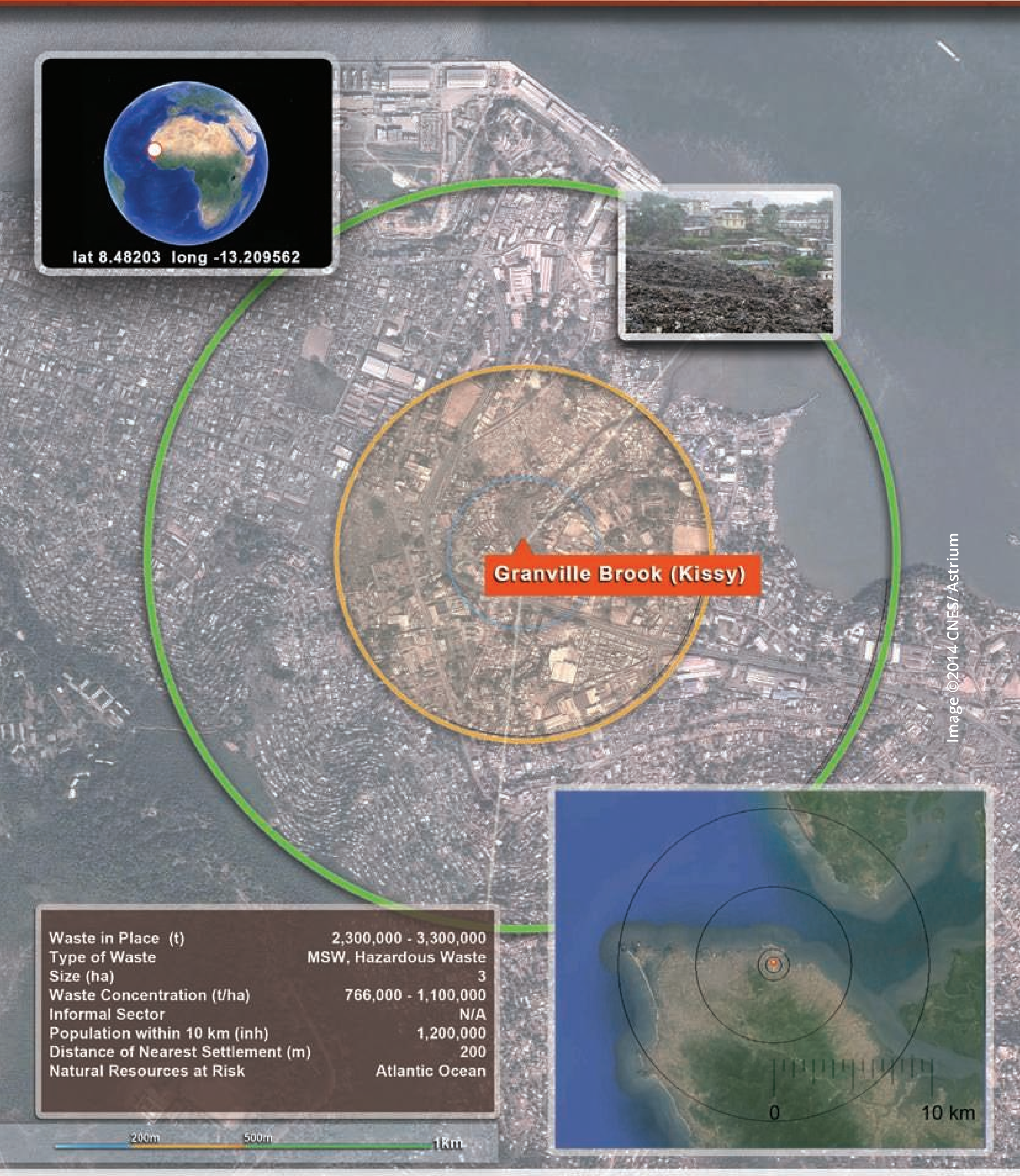
Eneka dumpsite is situated west of the City Port Harcourt, Nigeria along Igwuruta/Eneka road. The site lies on an area of 5 ha[1], which is flooded most part of the year; rainfall in the area exceeds 2,500 mm per annum. The site nowadays receives around 45,600 tonnes[1] of waste annually and is estimated that there are 8.4 to 12 million tonnes of MSW[2] in place. Waste pickers working on site suffer from malaria, parasitaemia, and blood problems related to high concentrations of heavy metals[1]. Groundwater, surface water and soil contamination from heavy metals as well as air pollution have been noticed in the area1. The nearest building to the dumpsite has a distance of about 200 meters[2] though initially the area was a thick bush and has been earmarked by the state government as an industrial area. It is estimated that the site affects around 1.2 million of people living within a radius of 10 km from it[3]. The site has a distance of 9 km from Okpoka River and Otamiri River[2].

# Nigeria - Lagos - Epe


| | |
|---|---|
| Waste in Place (t) | 33,000 - 47,000 |
| Type of Waste | MSW |
| Size (ha) | 80 |
| Waste Concentration (t/ha) | 412 - 580 |
| Informal Sector | 200 |
| Population within 10 km (inh) | 12,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Osogbo River, Lekki Lagoon |

Epe dumpsite is located in Lagos, Nigeria and covers an area of 80 hectares[1]. The site has been operating for 4 years with an annual input of 12,000 tonnes of MSW[2] in 2013 and so far there are 33,000 to 47,000 tonnes of waste in place[3]. The site has a distance of 500 meters from the nearest settlement, 2 km from Osogbo River and less than 7 km from Lekki Lagoon[3].

# Sierra Leone - Freetown - Granville Brook




| | |
|---|---|
| Waste in Place (t) | 2,300,000 - 3,300,000 |
| Type of Waste | MSW, Hazardous Waste |
| Size (ha) | 3 |
| Waste Concentration (t/ha) | 766,000 - 1,100,000 |
| Informal Sector | N/A |
| Population within 10 km (inh) | 1,200,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | Atlantic Ocean |

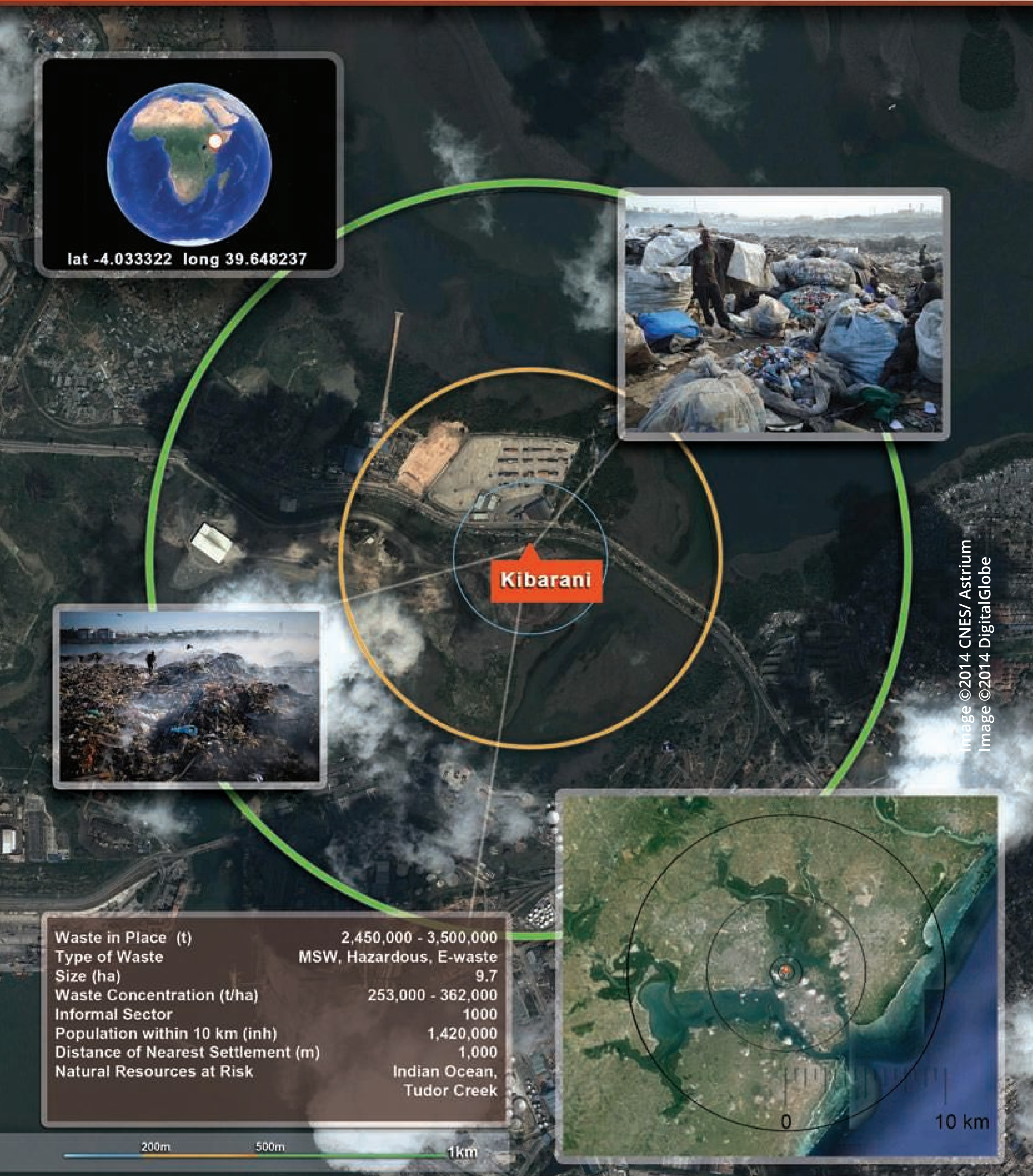
Granville Brook dumpsite or Kissy, is located in Sierras' Leone capital Freetown. It covers an area of 3 ha[1] and receives 272,000 tonnes[2] of MSW, Industrial, Hazardous and Medical waste[3] annually. The site practically started its operation at the end of the civil war and now counts 12 years[2] of operation. It is estimated that 2.3 to 3.3 million tonnes1 of waste have been disposed on the site. The dump is adjacent to dwellings and it is 1km away from Atlantic Ocean, causing fears for serious health problems and environmental impacts.It is estimated that almost 1.2 million people live within a 10 km radius from the site[1]. Due to its position the dumpsite has considerably made the residents to suffer from various diseases with malaria being the most prevalent. Smoke from open burning during the dry season, and underground water pollution during the raining season have been accused for chest pains, diarrhea, cholera and irritation of the skin, nose and eyes[4].

# Mozambique - Maputo- Hulene


| | |
|---|---|
| Waste in Place (t) | 1,750,000 - 2,500,000 |
| Type of Waste | MSW, Hazardous Waste |
| Size (ha) | 17 |
| Waste Concentration (t/ha) | 12,000 - 147,000 |
| Informal Sector | 500 |
| Population within 10 km (inh) | 2,700,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | Sea |

Hulene dumpsite is located in the capital of Mozambique, Maputo. It lies on a former wetland and it is close to an airport and a primary school[1]. The site, which covers an area of 17 ha[2], receives almost 290,000 tonnes[3] of Household, Commercial, Industrial and Medical waste annually. It has been assessed that around 1,750,000 to 2,500,000 tonnes[4] has been disposed on the site, since its opening 50 years ago[2,5]. The dumpsite is a poorly secured area, where more than 500 informal waste collectors[6] are searching for recyclables. There is a constant smoky haze over the dumpsite from open burning activities while groundwater contamination is reported during the rainy season. Colds, headaches, diarrhea, malaria, accidental cuts and backachs are main health problems faced by the scavengers. The site has a distance of 7 km from sea[4]. It is estimated that 2.7 million of people live within a 10km radius from the site[4].

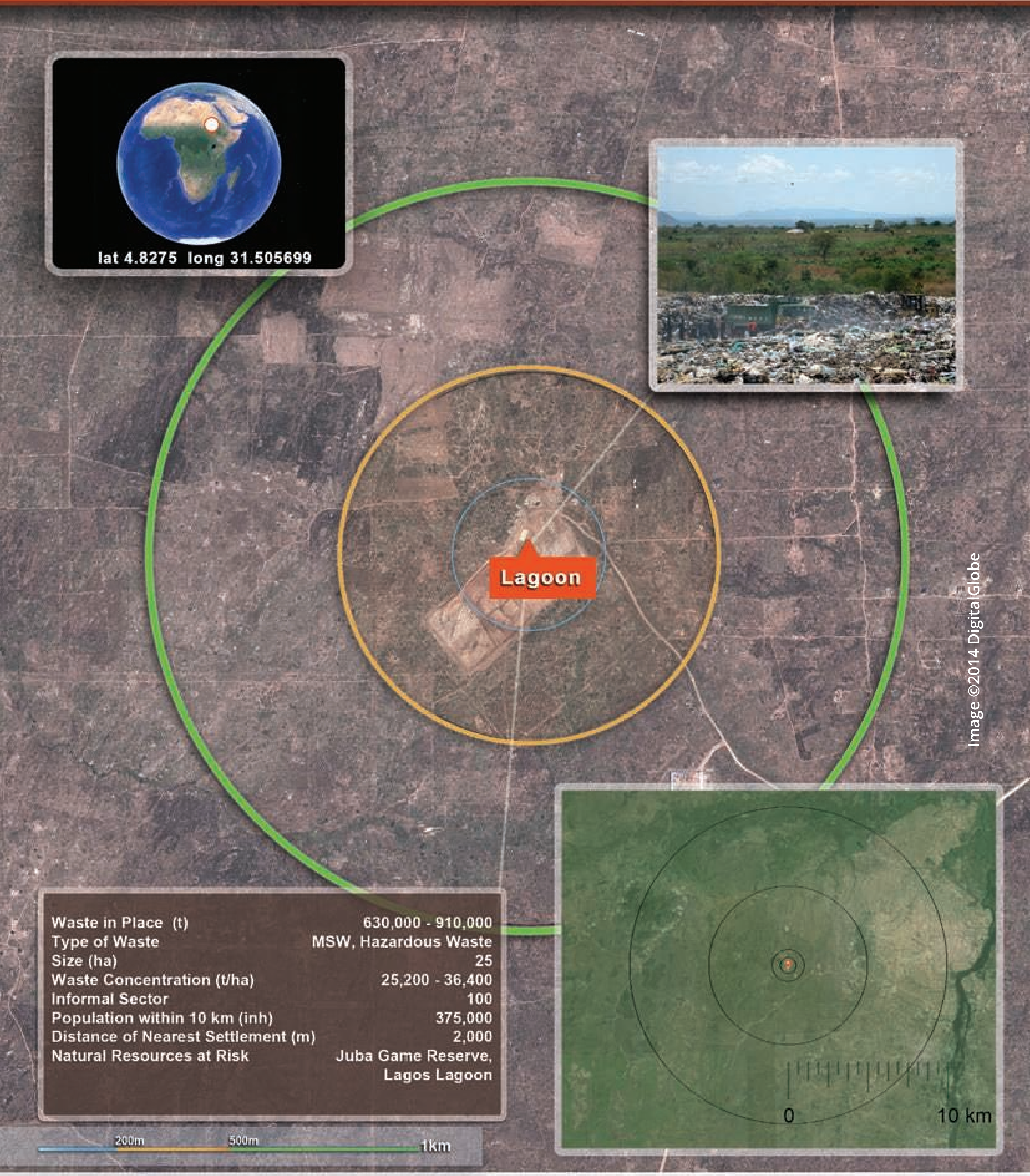
# Kenya - Mombasa - Kibarani




| | |
|---|---|
| Waste in Place (t) | 2,450,000 - 3,500,000 |
| Type of Waste | MSW, Hazardous, E-waste |
| Size (ha) | 9.7 |
| Waste Concentration (t/ha) | 253,000 - 362,000 |
| Informal Sector | 1000 |
| Population within 10 km (inh) | 1,420,000 |
| Distance of Nearest Settlement (m) | 1,000 |
| Natural Resources at Risk | Indian Ocean, Tudor Creek |

Kibarani dumpsite is located in Mombasa, Kenya nearby the Nairobi-Mombasa railway station[1] and it has been active for 40 years[2]. In an area of 11.4 ha[3], around 2.5 to 3.5 million tonnes[3] of MSW, Industrial, Medical, Hospital[4] and E-waste[5] have already been disposed. Nowadays, annual waste input reaches 146,000 tonnes. It is estimated that about 1,000 people live on the site; half of them make their living from retrieving recyclable materials from waste, especially E-Waste[6]. Furthermore, 1.4 million people lives within a 10 km radius from the site[3]. Health impacts are significant due to open burning activities of waste and mostly of E-waste which contain harmful substances such as mercury, lead, cadmium[6]. Finally, environmental impacts are of great concern as the site is adjacent to Indian Ocean and Tudor Creek[3]. The dumpsite and the road leading to it often get flooded during the rainy season, carrying leachate from the dumpsite into the sea[1].

# Republic of South Sudan - JUBA - Lagoon




| | |
|---|---|
| Waste in Place (t) | 630,000 - 910,000 |
| Type of Waste | MSW, Hazardous Waste |
| Size (ha) | 25 |
| Waste Concentration (t/ha) | 25,200 - 36,400 |
| Informal Sector | 100 |
| Population within 10 km (inh) | 375,000 |
| Distance of Nearest Settlement (m) | 2,000 |
| Natural Resources at Risk | Juba Game Reserve, Lagos Lagoon |

Lagoon Dump Site is located approximately 13 km from Juba Town Centre[1]. It covers an area of 25 ha[2] and accepts 182,500 tonnes of MSW, Medical and Hazardous waste[1] annually. Since its startup year in 2008, around 630,000 to 910,000 tonnes of waste have been disposed[2] on the site. Today, almost 100 waste pickers are working on the site searching for plastics such as PET bottles and nylon sacks, and metal scrap like aluminum and metal cans[1]. Waste pickers face problems related mostly to respiratory and skin diseases . It is of high concern that many of biomedical waste that contains items such as needles, syringes, soiled swabs, and bandages are being disposed in the site. It is clearly shown that the existing practices for biomedical waste are not working, and some hospitals and clinics are abusing the system by recklessly disposing of hazardous materials[4]. Items such as needles and soiled bandages expose the waste pickers to the risk of a range of infections including HIV/AIDS and hepatitis[3]. The site has a distance of 4 km from Juba Game Reserve[2].

# Nigeria - Ibadan- Lapite


| | |
|---|---|
| Waste in Place (t) | 95,900 - 137,000 |
| Type of Waste | MSW, Hazardous |
| Size (ha) | 20 |
| Waste Concentration (t/ha) | 4,700 - 6,800 |
| Informal Sector | N/A |
| Population within 10 km (inh) | 66,000 |
| Distance of Nearest Settlement (m) | 2,000 |
| Natural Resources at Risk | IITA Forest Reserve |

Lapite dumpsite is located in Ibadan, Nigeria. The site which has been active since 1998[1], covers an area of 20 ha[3] and receives around 9,000 tonnes[2] of MSW every year. It has been estimated that 95,900 to 137,000 tonnes of MSW[3] have been disposed on the site. The dumpsite is directly opposite a major road and there are vegetations at both sides of the road. There are few residential buildings, a re-habitation center, a petrol filling station and a few huts around the dumpsite.[4] The nearest settlement is at a distance of 2 km[3]. Due to open burning occurred on the site air pollution is significant, while heavy metals in the leachate that leakage from the site, poses great threat to the ground water and biodiversity near the area [3]. The dumpsite is located 9 km from IITA Forest Reserve a significant natural resource of the area[3].

# South Africa - Kagiso- Luipaardsvlei


| | |
|---|---|
| Waste in Place (t) | 2,450,000 - 3,500,000 |
| Type of Waste | MSW |
| Size (ha) | 5 |
| Waste Concentration (t/ha) | 490,000 - 700,000 |
| Informal Sector | 150 |
| Population within 10 km (inh) | 250,000 |
| Distance of Nearest Settlement (m) | 1,000 |
| Natural Resources at Risk | Walter Sisulu National Botanical Garden, Krugersdorp Municipal Nature Reserve, Robinson Lake |

Luipaardsvlei dumpsite is located at Kagaso, South Africa and covers an area of 5 ha[1].The site operates since 1980[2] and so far around 2.5 to 3.5 million tonnes of MSW are in place[3]. Annual waste disposal has reached 182,500 tonnes in 2013. It is estimated that 150 people reclaim recyclables for selling, and organic matter for feeding livestock at the dumpsite[1]. The site is located 7 km away from Walter Sisulu National Botanical Garden and Krugersdorp Municipal Nature Reserve, and 9 km away from Robinson Lake[3] causing environmental problems such as water contamination and biodiversity problems on flora and fauna[4].

# Senegal - Dakar - Mbeubeuss


| | |
|---|---|
| Waste in Place (t) | 7,350,000 - 10,500,000 |
| Type of Waste | MSW, Hazardous Waste |
| Size (ha) | 175 |
| Waste Concentration (tn/ha) | 42,000 - 60,000 |
| Informal Sector | 1,200 |
| Population within 10 km (inh) | 960,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Lake Mbeubeusse, Lake Malika, Lake Rose,Sea (Atlantic Ocean) |

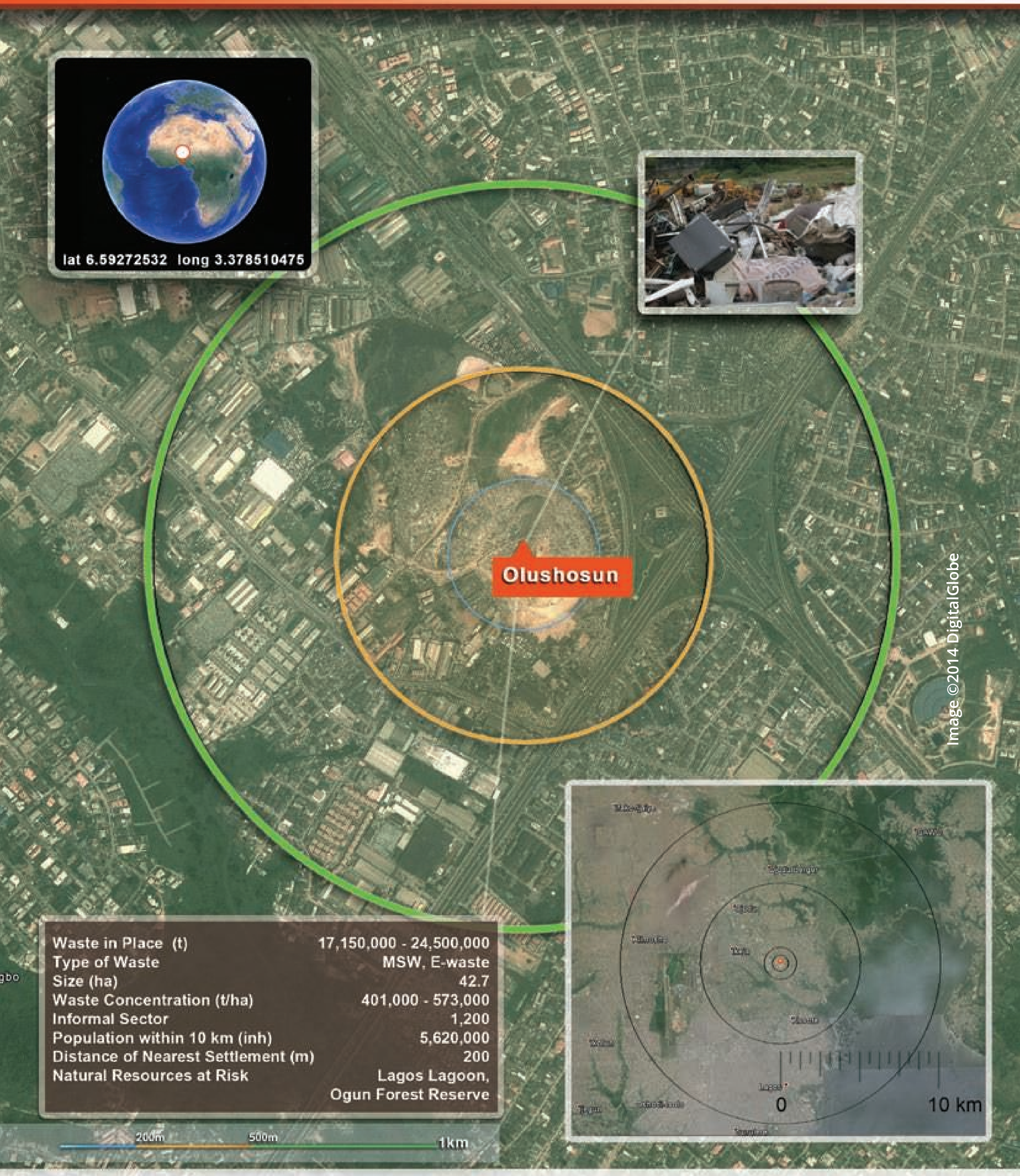
Mbeubeuss dumpsite is located at Malika, in Dakar, capital of Senegal[1]. It covers an area of 175 ha[2] and receives 475,000 tonnes[3] of MSW, Industrial and Hospital waste[4] every year. Since its opening 45 years[4] ago, an amount of 7.4 to 10.5 million tonnes of waste have been disposed[5] on the site. More than 3,500[5] people live around the dumpsite while 400 live within it and about 1,000-1,200 are scavenging to make a living[3,6]. In the site there is a health center, a literacy center, a credit and savings co-op, and a training center . Numerous health problems related to skin and respiratory diseases3 have been reported. Furthermore, environmental impacts are of great importance as the site is located near lakes, wells and the sea. More specific Mbeubeuss dumpsite is adjacent to Mbeubeuss lake and it is 2, 3.5 and 9 km away from Atlantic ocean, Malika lake and Rose lake respectively[5]. None of the wells located close to the site are used for drinking water due to contamination by metals and pathogenic microorganism. Finally, toxic fumes emitted by the dumpsite and high levels of POPs have been measured in atmosphere and in local eggs[4]. It worth to mention that almost 1 million people have settled at a 10 km radius from the site.

# South Africa - Pietermaritzburg- New England Road


| | |
|---|---|
| Waste in Place (t) | 2,450,000 - 3,500,000 |
| Type of Waste | MSW |
| Size (ha) | 19.1 |
| Waste Concentration (t/ha) | 128,000 -183,000 |
| Informal Sector | 300 |
| Population within 10 km (inh) | 173,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Msunduzi River |

New England Road waste dumpsite opened 25 years ago[1] and serves the greater Pietermaritzburg area in South Africa. The site receives around 140,000 tonnes of MSW[2] annually and covers an area of 19.1 ha[3]. It has been assessed that 2.5 to 3.5 million tonnes of waste have already been disposed on the site. Management by the Msunduzi Local Municipality has been problematic with the dumpsite often being on fire, having no functional leachate collection system and not being lined as per minimum requirements. In the site there are 300 waste pickers most of whom are women and a few children[2]. Many of the children have visible health problems such as stunted growth, runny noses, chest problems and skin infections[1]. Finally the site is located 500 meter from the nearest settlement and the Msunduzi River posing serious threat to the public health and the aquatic life of river[3].

# Nigeria - Lagos - Olushosun




| | |
|---|---|
| Waste in Place (t) | 17,150,000 - 24,500,000 |
| Type of Waste | MSW, E-waste |
| Size (ha) | 42.7 |
| Waste Concentration (t/ha) | 401,000 - 573,000 |
| Informal Sector | 1,200 |
| Population within 10 km (inh) | 5,620,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | Lagos Lagoon, Ogun Forest Reserve |

Olushosun (Olusosun) is the largest dumpsite in Lagos[1], receiving around 2,100,000 tonnes[2] of MSW, construction and E-waste[3] per year in an area of around 43 ha[2]. The site is active since 1992[2] and it is estimated that 17,150,000 to 24,500,000 tonnes[4] of waste have already been disposed in it. On the site, around 1,200 scavengers[5] look everyday for recyclables to make a living. All scavengers are organized in an association which recodes their number and their work in place[6]. Numerous health problems have been reported in a radius of 3 km from the site such as headache, nauseous feelings, skin irritations, dysentery, diarrhea and water related disease[7]. More than 5 million people live within a 10 km radius from the site[4]. The site is very close to Lagos Lagoon (5 km north east), causing water contamination due to high concentrations of heavy metals in the leachate that reaches surface and underground water . Also the site has a distance of 9 km from Ogun Forest Reserve[4].

# Tanzania - Pugu - Pugu Kinyamwezi


| | |
|---|---|
| Waste in Place (t) | 1,400,000 - 2,050,000 |
| Type of Waste | MSW, Hazardous Waste, E-Waste |
| Size (ha) | 65 |
| Waste Concentration (t/ha) | 21,000 - 31,500 |
| Informal Sector | 3,000 |
| Population within 10 km (inh) | 3,930,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | Mogo Forest Reserve, Kizinga River |

Pugu Kinyamwezi dumpsite is located in Pugu a village of Kisarawi, in Tanzania. Currently Pugu is the main dumping site for most of the solid waste generated in Dar es Salaam city[1]. The site has received 1,400,000 to 2,050,000 million tonnes[2] of Industrial, Agricultural, Domestic, Commercial, Institutional, Medical and other special wastes (yard wastes, batteries and electronic) waste[1] since 2009[3]. Nowadays, the site covers an area of 65 ha[2] and receives around 493,000 tonnes of waste annually[1]. In the site, 3,000 waste pickers[4] recover recyclables materials. Respiratory problems from open burning, injuries from sharp objects, skin diseases and diarrhea are the most common health problems reported among waste pickers[1]. It has also been noticed that a free range of livestock enters in the dumpsite and eat garbage. Water contamination of surrounding water bodies, used for various human activities including domestic use, has also been occurred. Furthermore, the site is located less than 200 meters from the nearest settlement and it influences around 4 million people in a radius of 10 km. Important natural resources such as Mogo Forest Reserve and Kizinga River are found in a distance less than 10 km from Pugu Kinyamwezi dumpsite[2].

# Nigeria - Lagos - Solous 2


| | |
|---|---|
| Waste in Place (t) | 4,000,000 - 5,750,000 |
| Type of Waste | MSW, E-waste |
| Size (ha) | 7.8 |
| Waste Concentration (t/ha) | 512,000 - 737,000 |
| Informal Sector | 350 - 400 |
| Population within 10 km (inh) | 4,197,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | --- |

Solous 2 is located in the capital of Nigeria, Lagos and occupies an area of around 8 ha[1] along University–Iba Road[2] less than 200 meters away from nearest dwelling[3]. The site has been active since 2006[1] and receives around 820,000 tonnes of waste annually[2,4]. It is estimated that 4 to 5.8 million of tonnes of MSW[3] are already in place. 350-400 scavengers works on the site sorting out shoes, plastics, glass and scrap and sell them in traders, while they also collect and dismantle the e-waste that reach the Solous dumpsite[5]. Due to the vulnerable sandy formations of the ground of the area, the leachate flows to the groundwater[6] causing contamination and turning water unsuitable for human consumption[7]. Almost 4 million people lives within a 10 km radius from the site[3].

# Asia

# Jordan - Zarqa - Al Akaider


| | |
|---|---|
| Waste in Place (t) | 5,250,000 - 7,500,000 |
| Type of Waste | MSW, Hazardous Waste |
| Size (ha) | 90 |
| Waste Concentration (t/ha) | 58,300 - 83,300 |
| Informal Sector | 40 |
| Population within 10 km (inh) | 130,000 |
| Distance of Nearest Settlement (m) | 7,000 |
| Natural Resources at Risk | Daraa reservoir |

Al Akaider dumpsite is located in Zarqa, Jordan and started its operation in 1981[1]. During its 32 years of operation 5,250,000 to 7,500,000 tonnes[2] of MSW, industrial wastewater from slaughterhouses, dairy industry, dyeing industry and chicken sludge have been disposed[3,4], in an area of 90 ha, where 40 waste pickers work[1]. Around 365,000 tonnes[1] of waste reach the site every year and wastewaters are being disposed at special evaporation ponds[2] near the site. The dumpsite has a distance of 7 km from Daraa reservoir[2].

# Jordan - Mafraq - Al Husaineyat


| | |
|---|---|
| Waste in Place (t) | 1,250,000 - 1,650,000 |
| Type of Waste | MSW |
| Size (ha) | 28 |
| Waste Concentration (t/ha) | 44,000 - 58,000 |
| Informal Sector | 30 |
| Population within 10 km (inh) | Campus with Refuges, no data available |
| Distance of Nearest Settlement (m) | 7,000 |
| Natural Resources at Risk | --- |

Al Husaineyat dumpsite is located in Mafraq, Jordan and it has been active since 1986[1]. During its 27 years of operation around 1.3 to 1.7 million tonnes[2] of MSW, Institutional, Residential, and Commercial Waste1 have been disposed in an area of 28 ha[2]. In 2009 the waste disposed at Al Husaineyat reached 62,050 tonnes[1]. Inside the site around 30 waste pickers have been employed to sort trash. Al Husaineyat dumpsite has been initially designed to operate as a landfill but the uncontrolled disposal practices has led to ground water contamination. Fluoride and chloride concentrations higher than Jordanian Drinking Water Standards (JDWS)[1] as well as high concentrations of Escherichia coli (E. coli) have been reported in analysis of underground water samples[1].

# Jakarta - Bekasi - Bantar Gebang


| | |
|---|---|
| Waste in Place (t) | 28,280,000 - 40,400,000 |
| Type of Waste | MSW |
| Size (ha) | 112 |
| Waste Concentration (t/ha) | 257,000 - 360,000 |
| Informal Sector | 5,000 |
| Population within 10 km (inh) | 830,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Cileungsi River |

Bantar Gebang dumpsite is located in Bekasi, Indonesia. The site operates since 1989[1] , and today it covers an area of 112 ha[2] . Every year around 230,000 tonnes of MSW[3] are disposed on the site and currently around 28.3 to 40.4 million tonnes[2] of waste are in place. The dumpsite constitutes a constant work and home for 5,000 waste pickers[4] who face diseases ranging from skin irritations to tuberculosis[5] and tapeworm[6] . 500 meters away from the site there is a residential area while 2.5 km away is the River Cileungsi[7] . In a radius of 10 km, 830,000 inhabitants are potentially influenced from the operation of Bantar Gebang dumpsite.

# Kygyzstan - Bishkek - Bishkek (BADS)


| | |
|---|---|
| Waste in Place (t) | 7,700,000 - 11,000,000 |
| Type of Waste | MSW, Other Waste |
| Size (ha) | 38 |
| Waste Concentration (t/ha) | 200,000 - 286,000 |
| Informal Sector | 1,000 |
| Population within 10 km (inh) | 1,163,000 |
| Distance of Nearest Settlement (m) | 1,000 |
| Natural Resources at Risk | Ala-Archa River |

Bishkek Authorized dumpsite (BADS) is located in Bishkek, Kygyzstan and has an annual input equal to 193,000 tonnes of MSW[1]. The site, which covers an area of 38 ha, has received around 7.7 to 11 million tonnes of waste[2,3]. On a yearly basis about 700-1,000 people are involved in collecting recyclables on the dumpsite with up to 200 of them working there on a typical day[4]. Burning of waste is widespread on the surface of the BADS and there is evidence of permanent underground fires within the waste with combustion emissions inhaled by local residents. Polluted water from the site collects in the clay pit to the north of the site and in the pond to the east of the site with a risk of contaminating the Ala-Archa River which is located only 500 meters away[3]. Although there is no independent evidence of health problems to local residents, the site is considered to be responsible for poor health by the residents to the west and south east of the site[4,5]. 1 million people living in a radius of 10 km from the site are potentially influenced by its operation.

# India - Bangalore - Bruhat Bangalore Mahanagara Palike (BBMP)


| | |
|---|---|
| Waste in Place (t) | 2,800,000 - 3,950,000 |
| Type of Waste | MSW |
| Size (ha) | 35 |
| Waste Concentration (t/ha) | 80,000 - 127,000 |
| Informal Sector | 0 |
| Population within 10 km (inh) | 384,000 |
| Distance of Nearest Settlement (m) | 1,000 |
| Natural Resources at Risk | Hoskote Lake, Rampura Lake, Bileshivale Lake, Yellamma Lake |

Bruhat Bangalore Mahanagara Palike is located in Bangalore, the third largest city of India[1]. The dumpsite has been in operation since 2008[2] receiving around 657,000 tonnes[3,4], of MSW annually. During its 6 years of operation, around 2.8 to 4 million tonnes of MSW have been disposed at an area of 35 ha[5]. The site has a distance of 1 km from the nearest settlement causing significant health impacts related to respiratory and kidney problems and illnesses like malaria which affect most children and old people[7]. Groundwater contamination[8] has been occurred with tanks and bore wells of the near village being polluted from leachate leakage, resulted in health problems and destruction of agriculture. Surface contamination may also be implemented[5] as the distance of the dumpsite from the surrounding lakes range from 3.5 km (Hoskote Lake), 5 km (Yellamma Lake, Rampura Lake) to 7 km (Bileshivale Lake)[5].

# Gaza strip - Deir al Balah - Deir al Balah


| | |
|---|---|
| Waste in Place (t) | 1,000,000 - 1,500,000 |
| Type of Waste | MSW, Other waste |
| Size (ha) | 6.1 |
| Waste Concentration (t/ha) | 245,900 - 250,000 |
| Informal Sector | N/A |
| Population within 10 km (inh) | 200,000 |
| Distance of Nearest Settlement (m) | 1,500 |
| Natural Resources at Risk | Sea |

Deir al Balah dumpsite is located in Deir Al Balh, a Palestinian city of Central Gaza Strip. The site operates since 1996[1] and it is estimated that 1 to 1.5 million tonnes[2] of waste have already been in place. In 2009, the incoming waste was 90,000 tonnes[1], disposed on an area of 6.1 ha[2]. The site has been designed to work as a landfill, and has a special tar in order to prevent the seepage of leachate into the groundwater. However, the uncontrolled disposal activities categorize the site as a dumpsite. Sea is at a distance of 7 km from the site[2].

# India - Mumbai - Deonar


| | |
|---|---|
| Waste in Place (t) | 11,900,000 - 17,000,000 |
| Type of Waste | MSW, Other Waste |
| Size (ha) | 132 |
| Waste Concentration (t/ha) | 90,100 - 128,000 |
| Informal Sector | 1,500 |
| Population within 10 km (inh) | 5,187,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Mithi River, Sea |

Deonar dumpsite is located in Mumbai, India and it is the oldest and largest dumpsite of the country[1]. It operates since 1927[2,3], and although it is supposed to have ceased its operation[4], the site is still active and receives more than 1.3 million tonnes of MSW, Biomedical waste[2] every year. In an area of 132 ha[1], 11.9 to 17 million tonnes of waste have been disposed[5]. On the site there are around 1,500 waste pickers[5]. Local residents from the nearby settlement5 (almost 200 m away) complain about odors and claim that the smoke from fires causes asthma and other respiratory ailments[3]. A study conducted by the Mumbai office of the National Environmental Engineering Research Institute (NEERI) and KEM hospital found that two localities abutting Deonar had high concentration of formaldehyde, a carcinogen substance[6]. 5 million people living at a 10 km radius from the site are potentially influenced from the operation of Deonar dumpsite, while natural resources at a distance less than 10 km are possible affected; sea is only 3.5 km from the site while Mithi River is situated 7 km away[6].

# India - New Delhi - Ghazipur


| | |
|---|---|
| Waste in Place (t) | 9,800,000 - 14,000,000 |
| Type of Waste | MSW, Hazardous Waste |
| Size (ha) | 30 |
| Waste Concentration (t/ha) | 326,000 - 466,000 |
| Informal Sector | 420 |
| Population within 10 km (inh) | 3,060,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | Yamuna River, Sanjay Lake |

Ghazipur dumpsite is located in the capital of India, New Delhim, operating since 1984[1] . During its 29 years of operation 9.8 to 14 million tonnes[2] of household waste, animal waste from poultry, fish market & slaughter house[3] and C&D[1] waste have been disposed on the site. In 2008, 803,000 tonnes of waste3 were dumped in the site, which now covers an area of 30 ha[2,3]. It is estimated that around 420 people work in the dumpsite; 180 children among them[4] Most of the waste pickers suffer from asthma, tuberculosis, skin diseases and burns from fires[5]. The site is adjacent to dwelling, it is 2.5 km far from Sanjay Lake and 7 km from Yamuna River[2]. There are indications that the groundwater has been contaminated[6] with heavy metals. It is estimated that at a radius of 10 km from the site there are around 3 million inhabitants who could potentially be influenced by the operation of Ghazipur dumpsite.

# Myanmar - Yangon - Htain Bin


| | |
|---|---|
| Waste in Place (t) | 2,350,000 - 3,400,000 |
| Type of Waste | MSW |
| Size (ha) | 48 |
| Waste Concentration (t/ha) | 48,900 - 70,800 |
| Informal Sector | N/A |
| Population within 10 km (inh) | 1,313,000 |
| Distance of Nearest Settlement (m) | 1,500 |
| Natural Resources at Risk | Yangon River |

Htain Bin dumpsite is located in Yangon, Myanmar and it has been active since 2002[1]. During its 11 years of operation 2.4 to 3.4 million tonnes[2] of MSW have been disposed on an area of 48 ha[2]. The site receives around 310,000 tonnes[2] of waste[1] every year. Yangon River is located 4.5 km from the site[2]. It is expected that almost 1 million people living within a 10 km radius from the site are influenced from its operation.

# Myanmar - Yangon - Htwei Chaung


| | |
|---|---|
| Waste in Place (t) | 1,800,000 - 2,600,000 |
| Type of Waste | MSW, Hazardous Waste |
| Size (ha) | 23 |
| Waste Concentration (t/ha) | 78,260 - 113,000 |
| Informal Sector | N/A |
| Population within 10 km (inh) | 242,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Ngamoeyeik Creek |

Htwei Chaung dumpsite is located in Yangon, Myanmar and it has been active since 2001[1]. During its 12 years of operation 1.8 to 2.6 million tonnes[2] of waste have been disposed on the site, covering an area of 23 ha[2]. Nowadays, around 224,000 tonnes[3] of MSW and hazardous waste[1] are disposed on the site on annual basis. The site location is only 500 meters away from the nearest settlement and Ngamoeyeik creek[2].

# Pakistan - Surjani - Jam Chakro (Surjani Site)


| | |
|---|---|
| Waste in Place (t) | 14,150,000 - 20,200,000 |
| Type of Waste | MSW, Other Waste |
| Size (ha) | 202.3 |
| Waste Concentration (t/ha) | 125,200 - 178,700 |
| Informal Sector | 5,000 |
| Population within 10 km (inh) | 5,000,000 |
| Distance of Nearest Settlement (m) | 2,500 |
| Natural Resources at Risk | Manghopir Lake, Lyari River, Hub Dam Canal |

Jam Chakro dumpsite is situated in Surjani town, Karachi, Pakistan and it has been in operation since 1996[1] . The site covers an area of 202.3 ha[2] and receives annually around 118,000 tonnes[3] of Domestic, Industrial and Hospital waste[1]. During its 17 years of operation 14.1 to 20.2 million tonnes[4] of waste have been disposed on the site. More than 5,000 workers live around Jam Chakro site sorting recyclables[5]. The area where the scavengers have settled is called Omar Goth and has no sanitation or healthcare facilities[5] . The whole community suffers from the smoke, swarms of flies, scavenger dogs[1] and allergies[6] . The site has a 7 km distance from Manghopir Lake, Lyari River and Hub Dam Canal[4]. The latter is the canal supplies potable water to Karachi[1]. It is expected that the dumpsite influences the life and health of almost 5 million people living within a 10 km radius from the site.

# Gaza strip - Gaza city - Johr al Deek


| | |
|---|---|
| Waste in Place (t) | 1,150,000 - 1,650,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 20 |
| Waste Concentration (t/ha) | 57,500 - 82,500 |
| Informal Sector | 50 |
| Population within 10 km (inh) | 520,000 |
| Distance of Nearest Settlement (m) | 1,000 |
| Natural Resources at Risk | Sea |

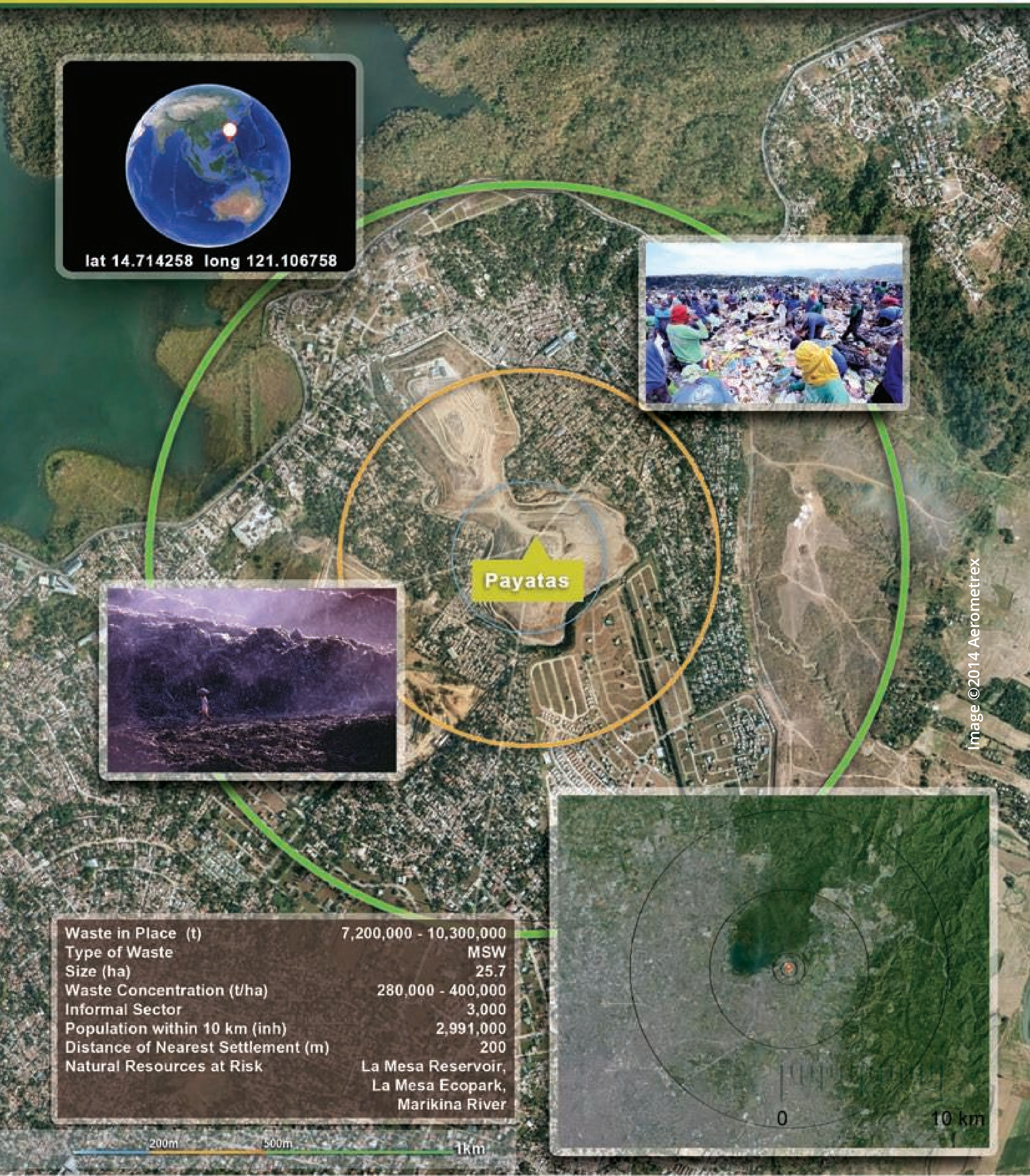
Johr al Deek dumpsite is located in Gaza city and it has been hosting uncontrolled dumping activities since 1987[1]. During its 26 years of operation 1,150,000 to 1,650,000 tonnes[2] of waste have been disposed on an area of 20 ha[2]. In 2011, 401,500 tonnes[3] of MSW, Slurry, Construction, Industrial, Medical and Hazardous waste1 disposed on site. On the site there are 20-25 waste pickers working all seasons, while their number increase to 50 at summer school vacations with 25 children[3]. The scavengers risk their life due to asbestos[4] presence and due to regular shots in the area[3]. The site has a distance of 1 km from the nearest settlement and 5 km from sea[2].

# Pakistan - Lahore - Mehmood Booti


| | |
|---|---|
| Waste in Place (t) | 5,500,000 - 7,850,000 |
| Type of Waste | MSW |
| Size (ha) | 25.5 |
| Waste Concentration (t/ha) | 215,600 - 307,800 |
| Informal Sector | N/A |
| Population within 10 km (inh) | 2,055,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Shahdara Reserve Forest, Ravi River |

Mehmood Booti dumpsite is situated in Lahore, Pakistan and started its operation in 1997[1]. Although it is mentioned in literature as a landfill, it does not have any environmental protection systems in place and the waste is openly exposed[1]. In an area of 25.5 ha[2] , there have already been disposed around 5.5 to 7.8 million tonnes[3] of MSW . Currently, the site receives 493,000 tonnes[3] of waste annually. The nearest to the site settlement is at a distance of 500 meters[3], while around 2 million people live within a 10 km radius from the site. Important natural resources are found at a distance less than 1.5 km; Ravi River[1,3] at 1km and Shahdara Reserve Forest at 1.5 km from the site. It is said that groundwater under and near the site has been seriously contaminated[1].

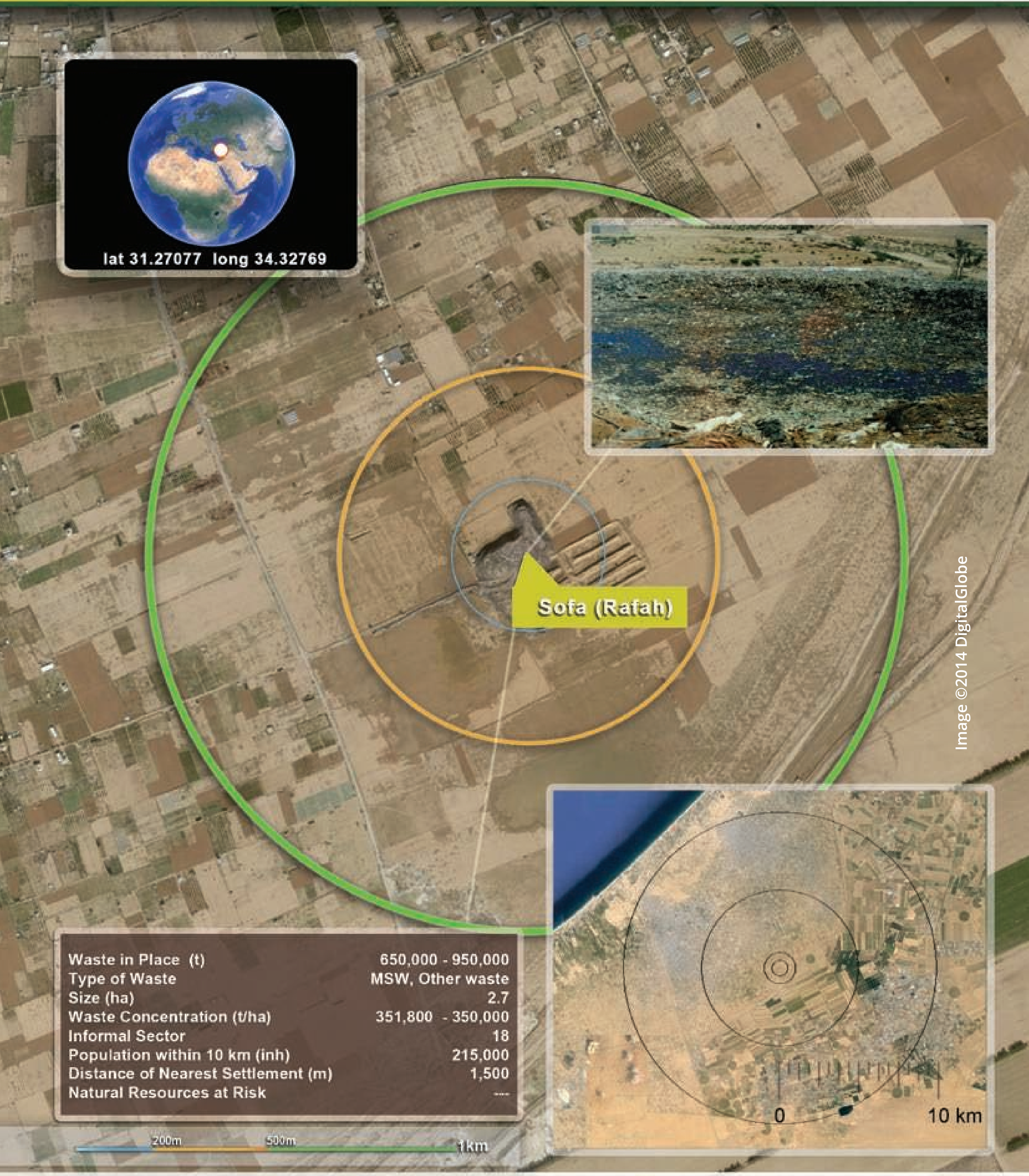
# Phillipines - Quezon City, Metro Manila - Payatas




| | |
|---|---|
| Waste in Place (t) | 7,200,000 - 10,300,000 |
| Type of Waste | MSW |
| Size (ha) | 25.7 |
| Waste Concentration (t/ha) | 280,000 - 400,000 |
| Informal Sector | 3,000 |
| Population within 10 km (inh) | 2,991,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | La Mesa Reservoir, La Mesa Ecopark, Marikina River |

Payatas dumpsite is located in Quezon City, Philippines and it is the largest open dumpsite of the country . Since its startup in 1973[2,3], 7.2 to 10.3 million tonnes[4] of MSW[5] have been disposed in the site covering an area of 25.7 ha[4]. Every day 520 trucks[6] deposit waste in the site with an estimate annual input equal to 438,000 tonnes of waste[7]. Around 3,000 scavengers[8] work on the dumpsite, in order to ensure the fed of their families[6]. The site is adjacent to settlement and about 200,000 people live along the dumpsite. During heavy rains many homes go beneath garbage as the site itself is unstable[9]. On July 11, 2000, a landslide of junk killed 218 people living on the dumpsite and caused 300 missing persons[1]. Residents have expressed nuisance about the smell[7] and health concerns have been raised as diarrhea[10] have been connected with the presence of sulfate and cadmium in drinking water.The site is only 1 km away from La Mesa Reservoir and Ecopark and 2km from Marikina River[4]. Almost 3 million people live within a 10 km radius from the site.

# Gaza strip - Rafah - Sofa




| | |
|---|---|
| Waste in Place (t) | 650,000 - 950,000 |
| Type of Waste | MSW, Other waste |
| Size (ha) | 2.7 |
| Waste Concentration (t/ha) | 351,800 - 350,000 |
| Informal Sector | 18 |
| Population within 10 km (inh) | 215,000 |
| Distance of Nearest Settlement (m) | 1,500 |
| Natural Resources at Risk | ---- |

Sofa dumpsite is located in Rafah, a Palestinian city in Gaza Strip. The dumpsite has been active since 1998[1] and currently has 650,000 to 950,000 tonnes[2] of waste in place. The site covers an area of 2.7 ha[2] and in 2009, received 63,000 tonnes of waste[1]. Around 20 people[3] work on the dumpsite sorting recyclables.

# Indonesia - Denpasar - Suwung


| | |
|---|---|
| Waste in Place (t) | 6,700,000 - 9,600,000 |
| Type of Waste | MSW |
| Size (ha) | 16 |
| Waste Concentration (t/ha) | 418,750 - 600,000 |
| Informal Sector | N/A |
| Population within 10 km (inh) | 288,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Sea |

Suwung Dumpsite or Pesanggaran as it is its official name[1] is located in Denpasar, Indonesia. The site operates since 1984[2] with almost 6.7 to 9.6 million tonnes of waste in place[3]. It covers an area of 16 ha[3] and receives around 288,000 tonnes of MSW every year[2]. Suwung dumpsite is situated on a swampy area covered with mangrove forests[3] and it is only 500 meters away from the nearest settlement[3] and the sea (Sanur beach).

# Timor-Leste - Tibar - Tibar


| | |
|---|---|
| Waste in Place (t) | 770,000 - 1,100,000 |
| Type of Waste | MSW, Hazardous Waste, E-waste |
| Size (ha) | 3.6 |
| Waste Concentration (t/ha) | 212,000 - 303,000 |
| Informal Sector | 100 |
| Population within 10 km (inh) | 240,000 |
| Distance of Nearest Settlement (m) | 1,500 |
| Natural Resources at Risk | Banda sea, Mota Comoro River, Tasitolu Lake |

Tibar disposal site is located in Tibar, Timor-Leste and it has been in operation since 1999[1]. In its 14 years of operation 770,000 to 1,100,000 tonnes[2] of waste have already been disposed, in an area of 3.6 ha[2]. The site receives annually more than 70,000 tonnes of MSW, chemical, C&D, E-waste[3] and medical waste[4]. Tibar dumpsite hosts around 100 waste pickers who work and live in dumpsite[5]. Significant natural resources are situated in a distance of less than 5 km from the site; Tasitolu Lake at 1.5 km, Banda Sea at 2 km and Mota Comoro River 3.5km[2]. Due to its position, Tibar open garbage dump poses threat to coast water quality[6].

# Europe

# Ukraine - Alushta - Alushta


| | |
|---|---|
| Waste in Place (t) | 600,000 - 850,000 |
| Type of Waste | MSW |
| Size (ha) | 3.5 |
| Waste Concentration (t/ha) | 171,000 - 242,000 |
| Informal Sector | 0 |
| Population within 10 km (inh) | 30,000 |
| Distance of Nearest Settlement (m) | 3,000 |
| Natural Resources at Risk | Sea |

Alushta dumpsite is located in Alushta, Ukraine and its operation started in 1960[1]. Currently, there are in place 600,000 to 850,000 tonnes of MSW [2], within an area of 3.5 ha[2]. The site receives around 40,000 tonnes[1] of waste every year and has been implemented in Clean Development Mechanism (CDM) project for methane capture and flaring[3]. Waste picking activities are allowed[1] in the site which is being secured.

# Serbia - Belgrade - Vinča


| | |
|---|---|
| Waste in Place (t) | 6,650,000 - 9,500,000 |
| Type of Waste | MSW, Hazardous waste, E-waste |
| Size (ha) | 35 |
| Waste Concentration (t/ha) | 190,000 - 270,000 |
| Informal Sector | 20 |
| Population within 10 km (inh) | 537,000 |
| Distance of Nearest Settlement (m) | 2,000 |
| Natural Resources at Risk | Danube River |

Vinča site is located in Belgrade, Serbia and during its operation around 6,650,000 to 9,500,000 tonnes[1] of waste have been disposed. The covered with waste area is 35 ha[2] and the site receives 700,000 tonnes of MSW,C&D, Non- Hazardous Medical waste and E-waste[2] annually. Although the site was designed to operate as a sanitary landfill but it does not meet the environmental standard of a landfill. There are 20 waste pickers scavenging for recyclable materials and leachate seeps are observed at various points in the side slope[3], since there is no leachate collection and treatment system in place. The site has a distance of 2 km from the nearest settlement and Danube River[1].

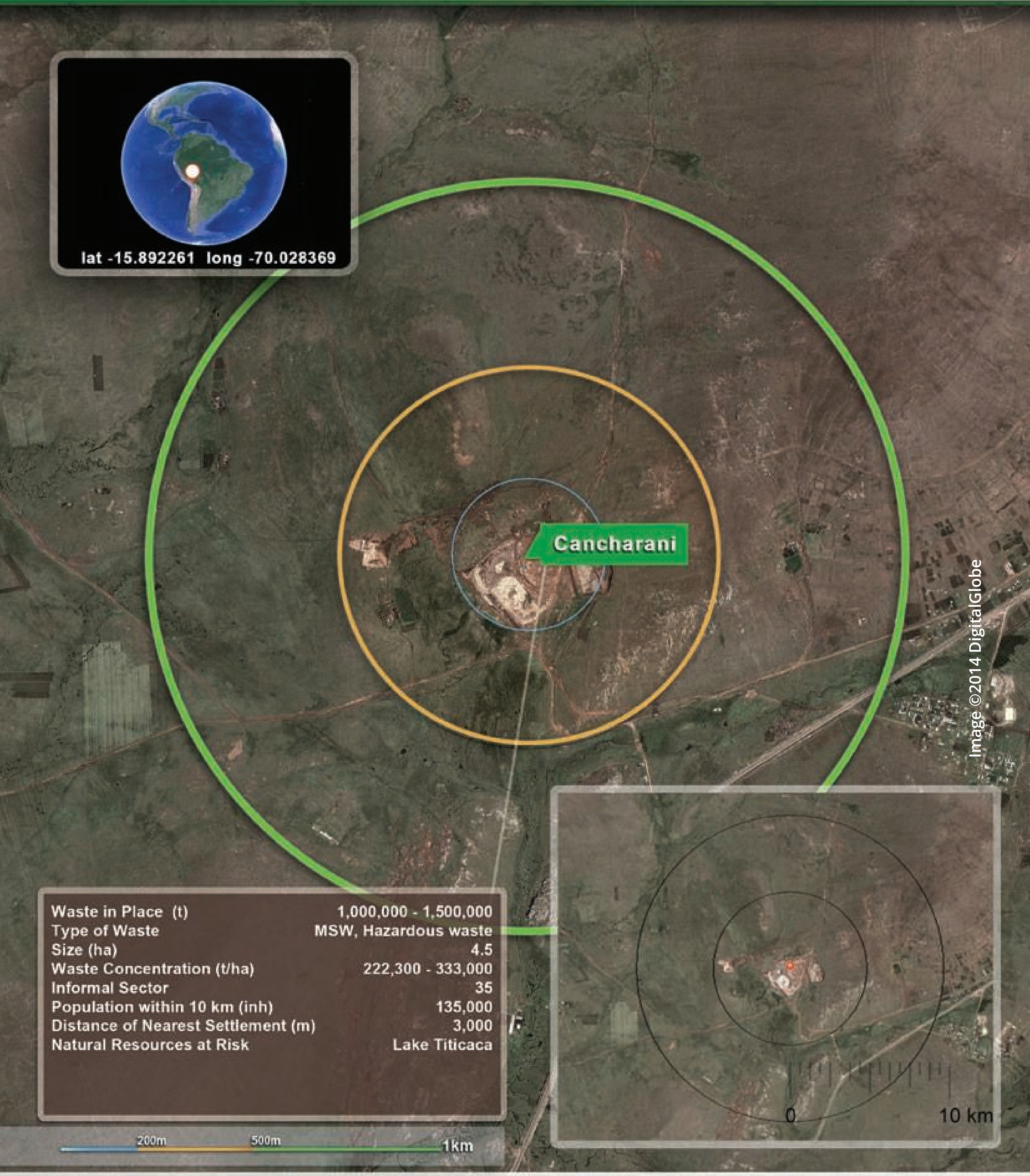
# Latin America

# Argentina - San Carlos de Bariloche - Bariloche


| | |
|---|---|
| Waste in Place (t) | 1,000,000 - 1,500,000 |
| Type of Waste | MSW |
| Size (ha) | 10 |
| Waste Concentration (t/ha) | 100,000 - 150,000 |
| Informal Sector | 200 |
| Population within 10 km (inh) | 115,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Gutierrez lake, Nahuel Huapi Lake |

Bariloche dumpsite is located in San Carlos de Bariloche, Argentina. The dumpsite that operates since 1985[1] has received 1 to 1.5 million tonnes of MSW[2] which have been disposed on an area of 10ha[1]. Nowadays, the site receives around 54,700 tonnes[1] of waste annually. In the site around 200 children scavenge for recyclables and food. The dumpsite is located 1.5 km from the nearest settlement, 3.5 and 7 km from Gutierrez Lake and Nahuel Huapi Lake, respectively[2].

# Peru - Puno - Cancharani




| | |
|---|---|
| Waste in Place (t) | 1,000,000 - 1,500,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 4.5 |
| Waste Concentration (t/ha) | 222,300 - 333,000 |
| Informal Sector | 35 |
| Population within 10 km (inh) | 135,000 |
| Distance of Nearest Settlement (m) | 3,000 |
| Natural Resources at Risk | Lake Titicaca |

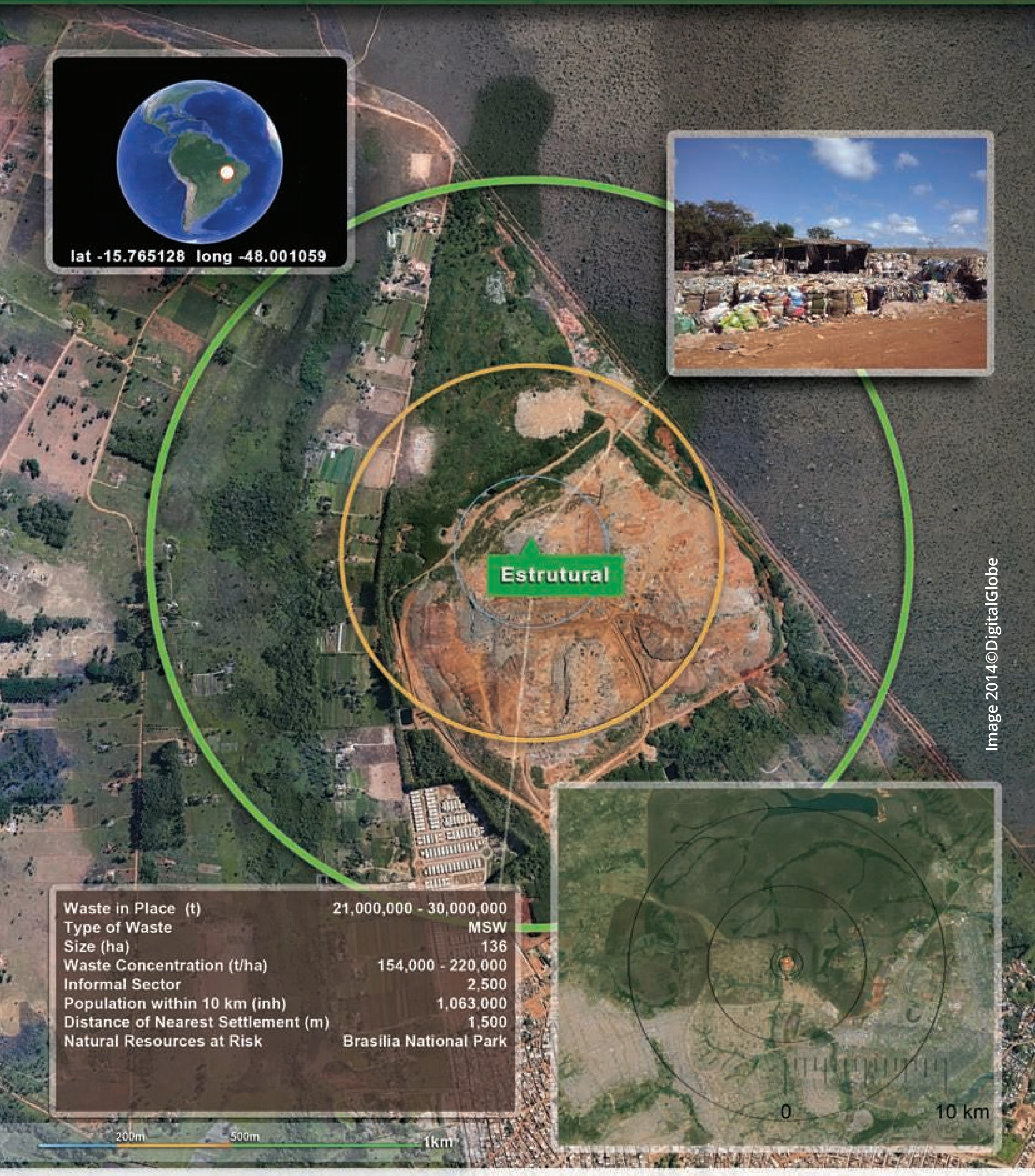
Cancharani dumpsite is located in Puno, Peru and it has been active since 1997[1] . During its 16 years of operation 1 to 1.5 million tonnes[2] of MSW and Hospital waste[2] have been disposed, covering an area of 4.5 ha[1]. Currently, 93,500 tonnes[1] of waste is disposed in Cancharani annually. The waste delivered at the site is a valuable resource for 35 waste pickers who work there[1]. The dumpsite has a distance of 3 km from the nearest settlement and 5 km from Titicaca Lake[2].

# Peru - Trujillo - El Milagro


| | |
|---|---|
| Waste in Place (t) | 2,000,000 - 2,900,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 58 |
| Waste Concentration (t/ha) | 34,400 - 50,000 |
| Informal Sector | 100 |
| Population within 10 km (inh) | 900,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Sea |

El Milagro is a dumpsite located in Trujillo, Peru and it has been active for 23 years[1]. It covers an area of 58 ha[1] and receives around 263,000 tonnes[2] of MSW and Hospital waste[1] annually. It is estimated that about 2 to 2.9 million tonnes[3] of waste have been disposed on the site. The 100 waste pickers, who are found in the dumpsite searching for food and recyclables, are facing diseases such as parasitolis, tuberculosis and AIDS[4]. On the site pigs fed with trash pose a significant threat for the health of near and distant populations, as in a later time they enter the market[5]. The dumpsite has a distance of 500 meters from the nearest settlement, while almost 900,000 people live with a 10 km radius from the site[3].

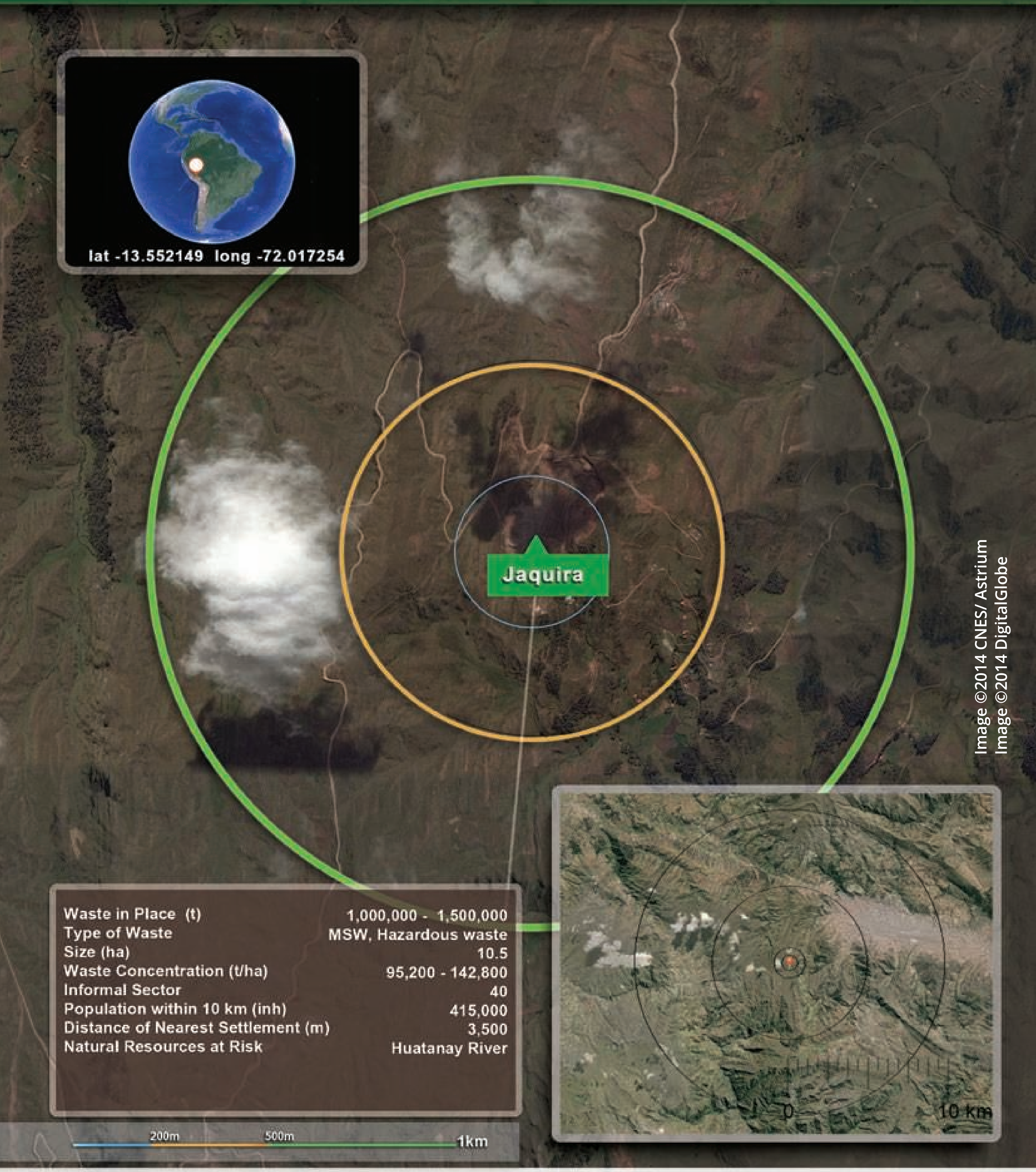
# Brazil - Brasilia - Estrutural




| | |
|---|---|
| Waste in Place (t) | 21,000,000 - 30,000,000 |
| Type of Waste | MSW |
| Size (ha) | 136 |
| Waste Concentration (t/ha) | 154,000 - 220,000 |
| Informal Sector | 2,500 |
| Population within 10 km (inh) | 1,063,000 |
| Distance of Nearest Settlement (m) | 1,500 |
| Natural Resources at Risk | Brasilia National Park |

Estrutural dumpsite is located in the capital city of Brazil, Brasilia and occupies an area of 136 ha[1]. It has been active for more than 50 years and currently 21 to 30 million tonnes[1] of MSW[2] have been disposed there. The incoming waste in 2013 was 2,000,000 tonnes[3]. In the dumpsite around 2,500 waste pickers live and work, making their monthly income by collecting recyclable, while around 1 million people live within a 10 km radius from the site[1]. Settlements made from cardboard and plastic are found on the mass of waste[3]. Unfortunately, many accidents and deaths have been reported within the dumpsite, the most recent, in 2013, is related to a wagon passes over the leg of a scavenger[2]. Environmental impacts are already visible as subsurface contamination has been reported. Furthermore, the fact that the National Park of Brasilia is only 500 meters away from the site rise concerns[4].

# Peru - Cusco - Jaquira (Haquira)




| | |
|---|---|
| Waste in Place (t) | 1,000,000 - 1,500,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 10.5 |
| Waste Concentration (t/ha) | 95,200 - 142,800 |
| Informal Sector | 40 |
| Population within 10 km (inh) | 415,000 |
| Distance of Nearest Settlement (m) | 3,500 |
| Natural Resources at Risk | Huatanay River |

Jaquira (Haquira) dumpsite is located in Cusco, Peru and it operates since 2001[1]. During its 12 years of operation 1 to 1.5 million tonnes of waste have been disposed on an area of 10.5 ha[2]. Currently, the site receives around 124,000 tonnes[1] of MSW and Hospital waste within a year. 40 waste pickers scavenging on the site for recyclables[1]. The dumpsite poses a serious threat for Huatanay River situated 3.5 km away from it[2]. Waste from the dumpsite is transferred with surface runoff into the river, causing insects' attraction and bacteria, and threatening fauna in areas of the lowland Amazon forest[3].

# Bolivia - Cochabamba - K'ara K'ara


| | |
|---|---|
| Waste in Place (t) | 2,800,000 - 4,000,000 |
| Type of Waste | MSW |
| Size (ha) | 25 |
| Waste Concentration (t/ha) | 112,000 - 160,000 |
| Informal Sector | 5,000 |
| Population within 10 km (inh) | 1,500,000 |
| Distance of Nearest Settlement (m) | 200 |
| Natural Resources at Risk | --- |

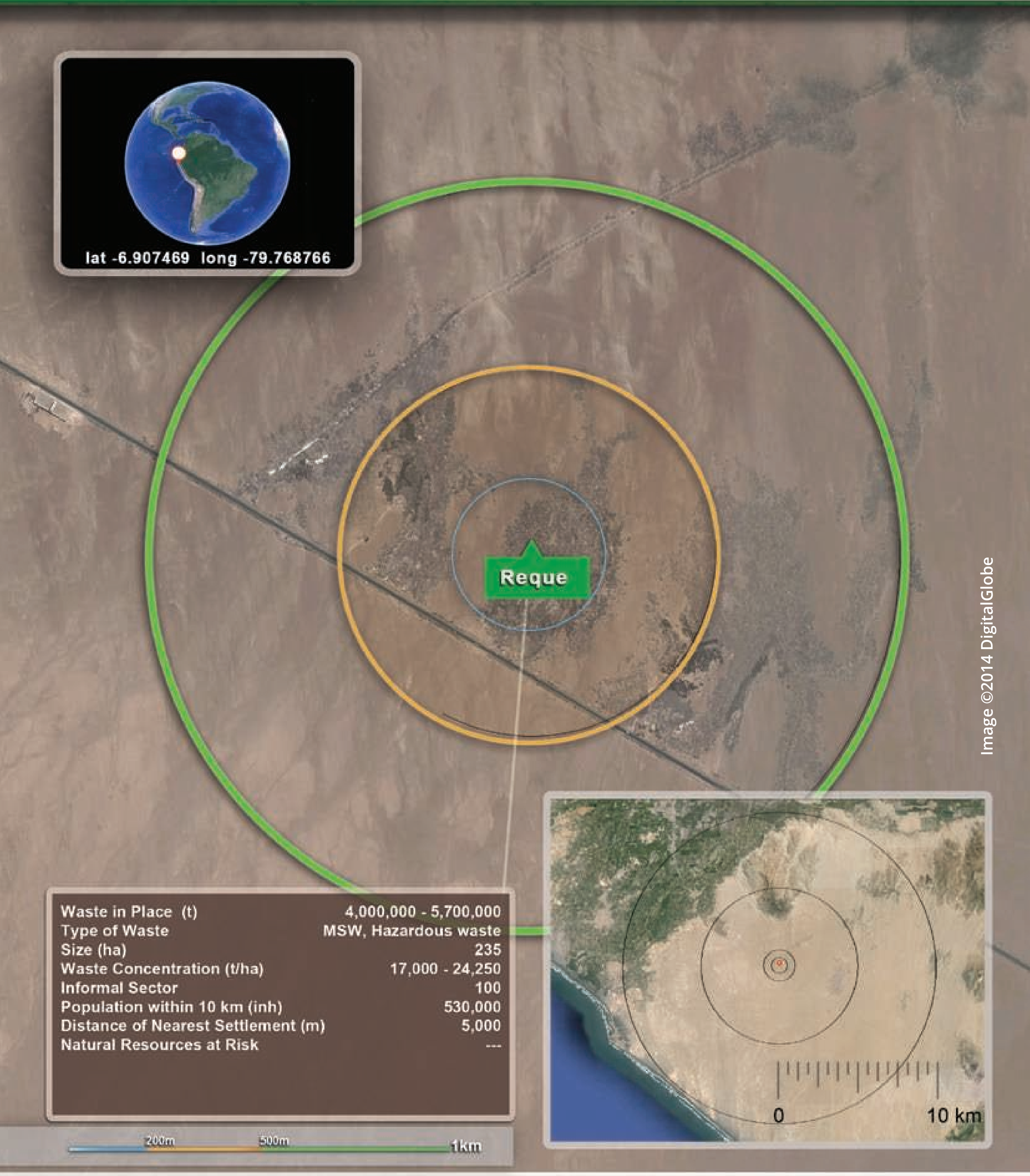
K'ara K'ara dumpsite located in Cochabamba, Bolivia and covers an area of 25 ha[1]. Currently, the site consists of two disposal sites; an inactive one which was used for 10 years[2], between 1988-1998, and an active one which operates the last 16 years. It is estimated that around 2.8 to 4 million tonnes[1] of MSW[2] have been disposed on the site. Recently, the active site has reached its capacity and a new dumping site is to be built on the inactive one[3]. The dump hosts 5,000 scavengers who search for recyclables to make their living[4]. The site has been a controversy issue between citizens and the municipality, due to its proximity to the nearest settlement (200 m) and health issues related to the operation of the dumpsite.

# Peru - Arequipa - Quebrada Honda


| | |
|---|---|
| Waste in Place (t) | 450,000 - 630,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 10 |
| Waste Concentration (t/ha) | 44,100 - 63,000 |
| Informal Sector | 70 |
| Population within 10 km (inh) | 942,000 |
| Distance of Nearest Settlement (m) | 2,500 |
| Natural Resources at Risk | --- |

Quebraba Honda dumpsite is located in Arequipa, Peru and it has been active since 2008[1]. During its 5 years of operation 450,000 to 630,000 tonnes[2] of MSW and Hospital waste[1] have been disposed on an area of 10 ha[1]. Currently, the dumpsite receives around 126,000 tonnes[1] of waste annually. The waste is shorted by the 70 waste pickers who work on the site on a daily basis[1]. Around 1 million people live within a 10 km radius from the site.

# Peru - Reque - Reque




| | |
|---|---|
| Waste in Place (t) | 4,000,000 - 5,700,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 235 |
| Waste Concentration (t/ha) | 17,000 - 24,250 |
| Informal Sector | 100 |
| Population within 10 km (inh) | 530,000 |
| Distance of Nearest Settlement (m) | 5,000 |
| Natural Resources at Risk | --- |

Reque dumpsite is located in Reque, Peru and it has been active for 35 years[1]. Around 4 to 5.7 million tonnes[2] of MSW and Hospital waste[3] have been disposed on an area of 235 ha[2]. The current annual waste disposal is 255,500 tonnes[3]. On the site there are 100 waste pickers who search for recyclables. Respiratory, intestinal, parasitic and skin diseases are of the main reported health issues that the people in and around the site faces[4]. Concerning environmental impacts proliferation of pests (flies), soil contamination and air pollution have been noticed[4].

# Caribbean

# Guatemala - Guatemala City- El Trebol


| | |
|---|---|
| Waste in Place (t) | 6,300,000 - 9,000,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 19.3 |
| Waste Concentration (t/ha) | 326,400 - 466,300 |
| Informal Sector | 2,000 |
| Population within 10 km (inh) | 740,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Zalia River, Chinautla River, Parque Ecologico, Jacarandas de Cayala |

El Trebol is located in the center of the Guatemala City and covers an area of 19.3 ha[1]. The site has been active since 1966 and receives around 300,000 tonnes[2] of Household, Commercial, Industrial and Hospital waste[3] every year. Currently, it is estimated that 6.3 to 9 million tonnes of waste have been disposed in the site[1]. 2,000 waste pickers, the "guajeros" as locals call them, work on the dumpsite[3]. Injuries and fatalities of waste pickers due to fires and waste slide accidents have been reported, while nauseating odor and proliferation of flies and other insects have been reported by residents of nearby villages[3]. Leachate from the dumpsite is accumulated in a lagoon and drains into the Zalia River, which joins the Chinautla River[3]. The dumpsite has a distance of 500 m from the nearest settlement and 4km from the Ecological Park of Jacarandas de Cayala[1].

# Nicaragua - Managua - La Chureca


| | |
|---|---|
| Waste in Place (t) | 6,300,000 - 9,000,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 42 |
| Waste Concentration (t/ha) | 150,000 - 214,000 |
| Informal Sector | 1,200 |
| Population within 10 km (inh) | 767,000 |
| Distance of Nearest Settlement (m) | 1,000 |
| Natural Resources at Risk | Managua Lake, Asososca Lagoon, Tiscapa Lagoon, Apoyeque Lagoon, Xiloa Lagoon |

La Chureca dumpsite is located in Managua, capital of Nicaragua and it has been active for 41 years[1]. Currently 6.3 to 9 million tonnes of MSW and Industrial waste[2] are in place. The annual waste input is considered 430,000 tonnes[1]. The site has a size equal to 42 ha, but only one third of this area is used for waste disposal[1]. The rest is covered with soil as part of the Spanish cooperation activities to improve the area[1]. 1,200 waste pickers live and work on the dumpsite collecting and classifying waste[3]. Important natural resources are found in a close distance from La Chureca dumpsite. The aquatic life of Managua Lake, 200 meters away from the site, is significantly influenced from the operation of the site[4]; high levels of mercury have been found at fishes[4]. Asososca Lagoon, Tiscapa Lagoon, Apoyeque Lagoon and Xiloa Lagoon are at 3, 4, 5 and 7 km away from the site respectively[2]. The nearest settlement is found within 1 km, while almost 700,000 people live with a 10 km radius from the site.

# Hondura - Tegucigalpa - Tegucigalpa


| | |
|---|---|
| Waste in Place (t) | 4,000,000 - 5,700,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 40 |
| Waste Concentration (t/ha) | 100,000 - 142,500 |
| Informal Sector | 1,500 |
| Population within 10 km (inh) | 800,000 |
| Distance of Nearest Settlement (m) | 1,000 |
| Natural Resources at Risk | Choluteca River |

Tegucigalpa dumpsite is located in Tegucigala city, Hondura, covering an area of 40 hectares[1]. Since its opening in 1977, 4 to 5.7 million tonnes[2] of Household, Industrial and Hospital Waste[3] have been disposed on the site. Annual waste input is around 310,250 tonnes[1]. Trash trucks and other vehicles arrive in a steady stream from sunrise to after sunset, bringing the city's daily refuse to the ever growing mountain of trash. 1,500 men, women and children work in the trash searching for recyclables and food[4]. Their homes are made of the scraps that they find in the dump[5]. Waste pickers, the "pepenadores", face skin diseases, hepatitis and malnutrition. In addition to illness, the people are exposed to biohazards such as used needles and other toxic chemicals that are brought into the dump. Furthermore, deaths of children run over by trucks have been reported[6]. The dumpsite is near Choluteca River (2.5km) posing threats to the aquatic life[2] while groundwater contamination has been reported[3].

# Haiti - Port au Prince - Trutier


| | |
|---|---|
| Waste in Place (t) | 2,100,000 - 3,000,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 94 |
| Waste Concentration (t/ha) | 22,300 - 31,900 |
| Informal Sector | 2,000 |
| Population within 10 km (inh) | 1,300,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Grise River, Sea |

Trutier Dumpsite is located at the capital of Haiti, Port au Prince and covers an area of 94 ha[1]. The dumpsite started to receive waste in 1980[2] and currently 2.1 to 3 million tonnes[3] of MSW, Medical[4] and C&D waste[1] are in place. In 2008 the incoming waste was around 320,000 tonnes. In the dumpsite 2,000 waste pickers[5], the "Kokorat"[1] as named by locals, scavenge for recyclables and food. Their number was raised from 200 to 2,000 after the earthquake in 2010[5]. Today, people working on the dump face diseases such as fever, anemia, headaches, eye infections, malaria, diarrhea, throat infections, infected cuts, typhoid, and stomach ulcers[1]. Furthermore, many accidents have been reported with young and agile scavengers run over by moving trucks[1]. Air quality is low due to active fires on the site, while ground and surface water is contaminated by leachate leakage from the dump into close located water resources[2]. The site is at a distance of 1 km from Grise River and 1.5 km from sea[3].

# Dominican Republic - Santo Domingo - La Duquesa


| | |
|---|---|
| Waste in Place (t) | 14,700,000 - 21,000,000 |
| Type of Waste | MSW, Hazardous waste |
| Size (ha) | 128 |
| Waste Concentration (t/ha) | 114,000 - 164,000 |
| Informal Sector | N/A |
| Population within 10 km (inh) | 225,000 |
| Distance of Nearest Settlement (m) | 500 |
| Natural Resources at Risk | Isabela River |

La Duquesa is the biggest dumpsite of Dominican Republic[1]. The site is located in the capital and largest city of Dominican Republic, Santo Domingo and covers an area of 128 ha[2] . Since its initial operation in 1996[3], 14.7 to 21 million tonnes of hazardous and non-hazardous waste[2] have been disposed on the site. In 2008 the incoming waste was 1,200,000 tonnes[3] . Unsuccessful, attempts have been made to transform the open dumpsite into a landfill with emphasis to recycling, production clean energy and composting activities[3,4] . The dumpsite is located only 2 km far from Isabela River causing threats to the aquatic life[2].

# STATISTICS

The following table presents the totals (sums, for five selected parameters) for all the 50 dumpsites already presented. In order to provide an easy measure of the order of magnitude of the totals, a third column provides comparable figures.

**Table 1.** Summarised Information of the 50 biggest active dumpsites

| Parameter | Summarised data | Comparison information |
|---|---|---|
| Annual Capacity (t/yr) | 22 million | 250% of the global coffee production (8.5 million in 2013)<br><br>40% of the global meat consumption (56 million tonnes in 2013) |
| Informal Sector Population | 52,620 | Cayman Islands population 57,570 (2012) |
| Size (ha) | 2,175 | 6 times Central Park (341 ha) |
| Population within 10km (inh) | 64.3 million | France's population 65.7 million (2012) |
| Waste in place (t) | 258-368 million | Global soybean production 189 million tonnes in 2013<br><br>China's rice production 141 million tonnes in 2013 |
| Total volume ($m^3$) | 573-817 million | 2.5 million $m^3$ is the volume of the Great Pyramid of Giza<br><br>500 million $m^3$ of ice are lost every year in Greenland and Antarctica due to global warming |

A basic statistic analysis regarding the 50 dumpsites is presented at the next 3 figures showing the dumpsites according to the type of waste included and the relation among annual capacity, informal sector and population within 10 km radius.

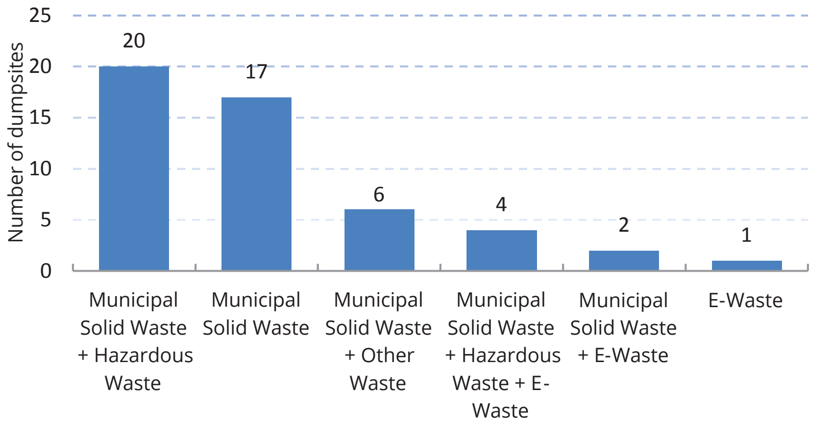



**Figure 1.** Number of dumpsites accepting different combinations of waste types. Almost all cases accept mixed municipal solid waste (MSW); and in almost half (24 out of 50) co-disposal of hazardous waste is practiced. Co-disposal of E-Waste is also common (6 out of 50), whereas in a few cases indescribable 'Other Waste' find their way there.

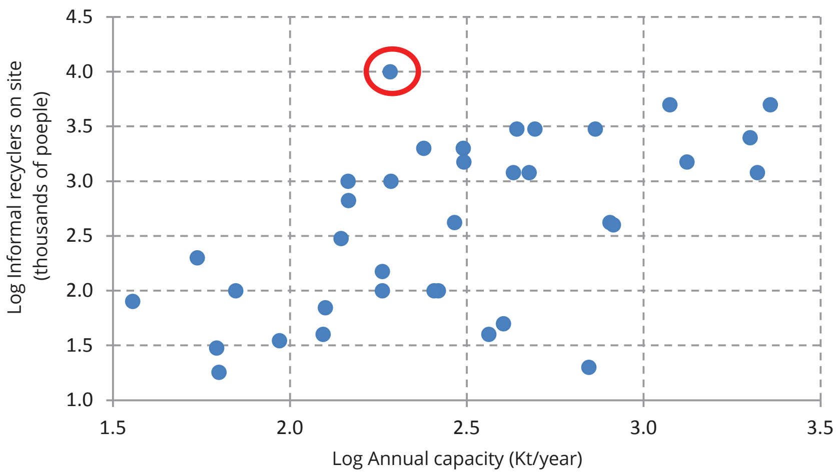



**Figure 2.** How many informal recyclers are associated with a dumpsite compared against the size of the place, measured as by the amount of the weight of waste it accepts per year (annual capacity)? The logarithms of both aspects reveal a slight linear relationship: more recyclers for landfills accepting more waste (Scatter-plot of Log Annual capacity (Kt/year) vs. Log number of informal recyclers) - coefficient of determination: $R^2$=0.31). If the Agbogbloshie site (in red circle), which accepts only E-waste and is a special case, is ignored, then the $R^2$ increases to 0.37.

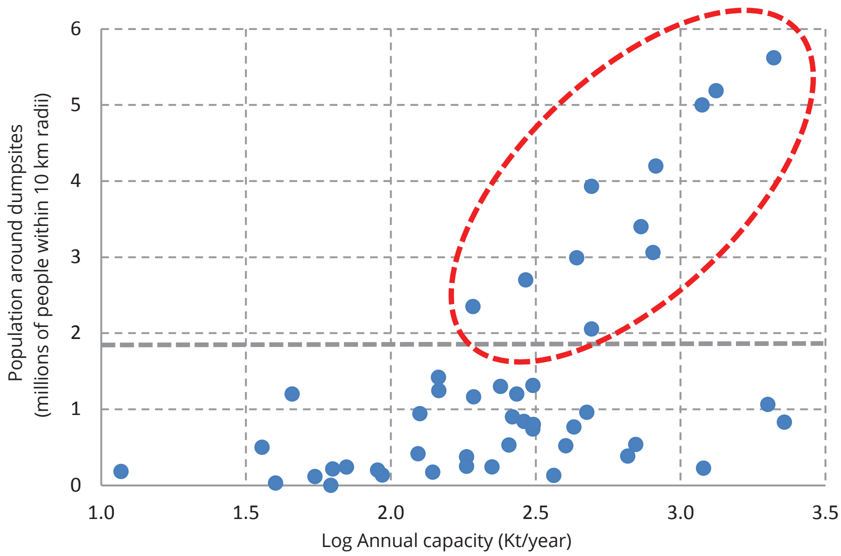



**Figure 3.** How many people live within a 10 Km radius around dumpsites in relation to the size of the dumpsite, measured by the amount of the weight of waste it accepts per year (annual capacity)? It seems that the logarithm of the annual capacity has a slight linear relationship with the number of people around dumpsites: bigger dumpsites can be generally associated with greater number of people living around them. This is much more evident for bigger populations living around dumpsites (> 2 million people within 10 Km radius) (Log Annual capacity (Kt/year) vs. Population around the dumpsites (millions of people) - coefficient of determination: $R^2$=0.31; if only the cases with population above 2 million is considered - red dotted area - then the $R^2$ is at 0.74).

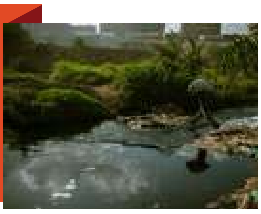

So what the typical 'monstrous' dumpsite looks like around the world, measured as the median for each variable (50%, middle value for the ordered 50 cases under examination)? It is accepting mixed (unprocessed) municipal solid waste (MSW), and it should not be surprising to find out that hazardous waste is co-disposed. It could be having at least 2.5 million tonnes (Mt) of waste already disposed of and remaining in place, could occupy the space of 24 ha (24 times 10,000 $m^2$: the size of around 29 big international football fields), could be operating for 17 years now, and having an annual capacity of 267 Kt. This average 'monstrous' dumpsite would have something less than a million people (0.83) living within 10 km radius of its centre, with the nearest settlement being close by: just within half kilometre. Around 1,300 informal recyclers could be making a living from the dumpsite.

In order to highlight the significant impacts caused by the unsound disposal of waste in open dumpsites and the variety of their interaction with the local ecosystems, five representative case studies have been selected. They are briefly presented in ANNEX IV, while several links and sources are provide so the readers can study further the details for each dumpsite. The Waste Atlas Partnership emphasises the need to study dumpsites in more depth, especially their health and environmental impacts, in order to support decision-making towards their closure. The following case studies are presented:

1. Agbogbloshie, The Health Impacts

2. Bantar Gebang, An Informal Recycling Habit

3. Dandora, An Environmental Disaster



4. Estrutural, The Biggest Active Dumpsite in Brazil

5. Leuwigajah, Dumpsites & Fatal Accidents

# FINDINGS & CONCLUSIONS

This report is a first effort to list the world's biggest (and probably riskiest) dumpsites. The major findings of the report are listed below.

- Dumpsites are situated near or even within populated urban areas and almost all of them (42) have settlements in a distance smaller than 2 km.
- 64,285,000 inhabitants are living in less than 10 km distance from the 50 dumpsites profiled. There is a slight linear relationship between the population living in 10 km radius and the waste received annually, the more the population the more the waste received.
- More than 52,500 informal recyclers are working and make their living in those 50 dumpsites. In many cases informal recyclers have their homes nearby or even inside the dumpsites. There is a slight linear relationship between the number of informal recyclers and the size of the dumpsite, the more the size of the dumpsite the more the informal recyclers working there.
- 44 out of the 50 dumpsites under study are very close to natural resources (less than a 10 km distance), including several rivers and lakes, which are certainly affected.
- Environmental pollution is a fact around the dumpsites. Air pollution due to open burning and ground water contamination are the most frequent impacts.
- Health problems were difficult to be assessed and quantified; however in several cases there are reports, which indicate important health impacts.
- The annual waste disposed of to those 50 dumpsites is more than 21,5 million tonnes per year and the waste in place is between 258-368 million tonnes.
- The total area covered by waste is 2,175 hectares.
- Hazardous waste are disposed in 24 out of the 50 studied dumpsites.
- E-waste are disposed in 7 out of the 50 examined dumpsites

Gathering the evidence was far from straightforward: scientific and 'grey' non-peer reviewed literature were both scanned for information on dumpsites. Somehow not surprising, the scientific evidence on the topic is limited. What made the report more valuable was the data sharing from local experts, to whom Waste Atlas partners are grateful for their enthusiastic key contribution of otherwise inaccessible or obscure information.

This demonstrates the power of the Waste Atlas in mobilising expertise and collecting scientific and lay knowledge on transformative topics of landmark nature, materialised with relatively minimal resources. However, it also demonstrates inevitable limitations and barriers to be overcome in future efforts, such as the obvious gap of relevant information within China.

During the data acquisition, the lack of a globally accepted and validated methodology supporting uniform data collection and interpretation for dumpsites was realised. This issue is of high importance and the global scientific community has to prioritise it accordingly in order to create relevant tools and methodologies.

Finally, there is a need for further research in order to create more complete and accurate data sets for dumpsites and to expand this list to the 100 and even better the 1,000 world's biggest dumpsites. The Waste Atlas Partnership calls all the relevant international stakeholders to cooperate for the realisation of similar projects that will contribute to a better understanding of the global waste management challenge.

## METHODOLOGY

A consistent research methodology was followed in order to make the presented data comparable, accurate and uniformly reported. The data management and selection of the World's 50 biggest active dumpsites was performed in four phases:

1. Initial data collection
2. List of selected data
3. Evaluation and selection of 50 'biggest' sites
4. Statistical analysis

**1. Initial Data Collection**

In phase 1, primary raw data was collected. The first data set collected from the existing entries in the Waste Atlas Database. Key aspects were the size and the annual capacity of the dumpsites. Given the data paucity on the topic, additional data were sought using a suitable pro-forma template created with the collaboration of the University of Leeds. A crowdsourcing campaign was widely and openly communicated, including also targeted communication with selected important stakeholders. Responses were obtained by both individual experts and organisations. Another set of data was obtained by thorough review of the published literature, including both peer-reviewed publications and 'grey' sources, such as reports and news media. For the cases identified in these two datasets, a more focused research was performed for reported environmental and public health impacts due to the operation of each dumpsite, as well as the number of the informal sector recyclers living and working on the sites. Data for the former were mainly obtained from individuals living close to dumpsites and some organisations; whereas data for the later were mainly sourced from the literature. All gathered information has been cross checked for reliability and time relevance. Where multiple sources where available these were cross-checked against each other.

**2. List of Selected Data**

In phase 2, all cases collected were split into two categories: (i) the first included data with accurate information and geographical position; (ii) and the second data without exact location and/or sufficiently complete or confirmed information. Dumpsites of the first category were selected to be further processed, so that all or almost all fields of information would be eventually covered. These dumpsites formed the final list considered in the next evaluation phase. Notably, the list contains dumpsites constructed initially as engineered landfills, but never being managed as such.

**3. Evaluation and Selection of 50 'Biggest' sites**

In Phase 3, the final list of the 'World's 50 Biggest Dumpsites' was determined, based on a multi-criteria evaluation procedure, considering:

-Size (ha)
-Annual waste disposal (t/yr)
-Years of operation (yr)
-Informal sector size (No. of people)
-Population within 10 km radius (inh.)

Each dumpsite was scored against each of the selected criteria, with equal weight. Other criteria, which could have been utilised are: 'Waste in place', 'Distance from natural resources' and 'Environmental and health impacts'. However, such information was difficult to be acquired and quantified, thus they were not taken into account during selecting the list of the World's 50 'biggest' active dumpsites.

**Data Presented in the Report**

*Type of Waste*

In dumpsites, many types of waste can be found. In the report for comparison purposes four categories of waste were used: 'Municipal Solid Waste', 'Hazardous Waste' and 'E-Waste' and unidentified 'Other Waste'.

*Size (ha)*

The size of a dumpsite was estimated as the area that is covered with waste. The unit selected is hectares (ha) (10,000 $m^2$); both literature data and GIS measurements were used.

*Annual Waste Disposal (t/yr)*

Annual Waste Disposal refers to the amount of waste, expressed in tonnes (t), which are being disposed of every year (yr). Information has been obtained from literature, relevant organisations and companies responsible for the operation of the sites..

*Years of Operation (yr)*

Years of operation represents the number of years a dumpsite is active. In the current study, operative years were counted from the startup year until 2013. Data for the startup year have been obtained from literature, companies and crowdsourcing.

*Informal Sector*

"The informal solid waste sector refers to individuals or enterprises who are involved in recycling and waste management activities but are not sponsored, financed recognized or allowed by the formal solid waste authorities, or who operate in violation of or in competition with formal authorities[2,3]." Informal sector in the present report represents only people that live and/or working in the dumpsites. The evidence regarding informal sector living and/or working in the dumpsites have been obtained from contributors, literature and organisations that holds relative data.

2 Scheinberg A, Simpson M, Gupt Y, Anschütz J, Haenen I, Tasheva E, et al., Economic Aspects of the Informal Sector in Solid Waste Management. Eschborn: GTZ (German Technical Cooperation), 2010
3 Costas A Velis, David C Wilson, Ondina Rocca, Stephen R Smith, Antonis Mavropoulos and Chris R Cheeseman, An analytical framework and tool ('InteRa') for integrating the informal recycling sector in waste and resource management systems in developing countries, Waste Management Research, 2012 30, 43-66p [I think we cite this form another source: please use also the reference to the initial source], Available at http://wmr.sagepub.com/content/30/9_suppl/43 (accessed on 16th June 2014)

*Population and natural resources within 10 km*

Population within 10 km refers to the number of people living around a dumpsite in a radius of 10 km from the apparent center of the dumpsite. Likewise, natural resources within 10 km enlist main natural resources such as rivers, lakes and forests within the name area.

The radius of 10 km was selected as a uniform representative, but still arbitrary, distance from the dumpsite, in order to perform comparative statistics and visualisations. The order of magnitude of 10 km can be considered as an outer 'influence zone' for dumpsites, and, hence, it represents "worst case scenario' for the potentially affected population and natural resources.

Population within the radius of 10 km has been estimated by relating the surface and borders of the urban and/or rural areas included in the radius of the 10 km to the overall number of urban and/or rural nearby population. The surface and borders of the urban and/or rural areas are provided by the ERSI[4] database. Population of urban and/or rural areas has been obtained from Wikipedia[5] if other more reliable local sources were not available.

*Waste in place (t)*

Several ways were used to assess waste in place, depending on the available data. Assumptions and calculations:

**1st**: Data for the total waste in place has been obtained from various sources (papers, D-waste, contributors). The presented information is referred to the most recent data found.

**2nd**: Where data were available as volumes ($m^3$), these were transformed to weight (tonnes) by multiplying with an average waste density of 0.45 $t/m^3$[6,7].

**3rd**: Where dumpsites operate less or equal to 15 years, waste in place was assessed by multiplying the annual capacity (t/yr), with operative years until 2013. Where dumpsites operate for more than 15 years, waste in place was estimated, taking into account the evolution of the served population and the waste generation per capita.
Since there is a lot of uncertainty in the way the waste in place was calculated, the range of values provided for each dumpsite can only be considered as a preliminary estimate.

Since there is a lot of uncertainty in the way the waste in place was calculated, the range of values provided for each dumpsite can only be considered as a preliminary estimate.

*Distance of nearest settlement (m)*

Distance of nearest settlement refers to the distance between the center of the dumpsite and the nearest group of dwellings. Distances are organized in buffer zones with non-continuous values of: 200; 500; 1,000; 1,500; 2,000; 2,500; 3,000; 3,500; 4,000; 4,500; 5,000; 7,000; 9,000; 10,000 m. Data have been obtained from GIS maps.

4 www.ersi.com

5 www.wikipedia.org

6 Michael L. Leonard, Sr., Kenneth J. Floom, Jr., and Scott Brown,Estimating Method and Use of Landfill Settlement,Environmental Geotechnics, 2000, 1-15p

7 Samson Ojoawo, Oluwole Agbede, Abimbola Sangodoyin, On the Physical Composition of Solid Wastes in Selected Dumpsites of Ogbomosoland, South-Western Nigeria, Journal of Water Resource and Protection, 2011, 3, 661-666p

*Waste Concentration (t/ha)*

Waste concentration refers to the amount of tonnes of waste that were already disposed of in a hectare (ha) of the disposal site. For its calculation waste in place and size of the site are used.

**4. Statistical Analysis**

Statistical analysis of the collected information was performed by University of Leeds. For the purposes of this report, it was limited to descriptive statistics. Scatterplots were plotted to visually inspect potential relationships between the variables. Where interesting relationships were evident the coefficient of determination ($R^2$) was obtained and reported. Most of the variables under consideration presented highly asymmetric distributions, skewed toward the lower values, with long tails towards the high values. Thus, a non-parametric statistic (median, 50% of the values), with greater robustness to extreme values and outliers was selected in constructing the profile of the average big dumpsite.

## DUMPSITES & ENVIRONMENT

ISWA
General Secretariat
Vesterbrogade 74
DK-1620 Copenhagen V
Denmark
www.iswa.org

### Key Issue

### Closing of open dumps

***The purpose of this Key Issue paper is to highlight the issues associated with open dumping, which is used as a waste disposal option in many developing countries. ISWA supports initiatives associated with moving away from open dumping to practices where the waste is better contained and covered, and environmental impacts from waste disposal are progressively reduced.***

***This paper is broad and generic, and is intended only to provide a framework of issues that need to be addressed in progressively reducing open dumping where this is still practiced.***

**Introduction**

The term “open dump” is used to characterize a land disposal site where the indiscriminate deposit of solid waste takes place with either no, or at best very limited measures to control the operation and to protect the surrounding environment.

The visual characteristics of such sites are typically:

1. Engineering

- Widely spread un-covered waste
- Open fires and/or waste periodically on fire
- No recording or inspection of incoming waste
- No control of waste placement
- No compaction of waste
- No application of cover soil, or minimal cover (often associated only with forming access roads)
- Leachate unmanaged and released to the surrounding environment
- Landfill gas unmanaged.

2. Planning

- Unorganized scavenging at site
- No security
- Uncontrolled waste management practice
- Free service policy
- Opposition from neighbours
- Vermin, dogs, birds and other vectors often prevalent

In addition, it is typical that no planning (such as location sensitivity) or engineering measures (such as a liner system) have been implemented prior to placement of waste. An open dump is the lowest classification of the solid waste disposal option of landfilling, whereas sanitary landfill (with emissions management) is the highest classification. In between there are differing levels of landfilling with varying levels of engineering and environmental controls. These vary from region to region and/or from nation to nation.

Throughout history, mankind has used dumps to solve solid waste problems. In the past, when waste streams were simple and land constraint was not a challenge, open dumping was used as an inexpensive and often appropriate solution. It served the purpose of keeping waste separated from the populace, hence limiting exposure to disease vectors, as well as odour and other direct effects. However, the introduction of more and more complex products into the waste stream (complicating disposal), increasing urbanisation and population growth have all resulted in a huge increase in the impacts of open dumps in many situations..

From today's point of view the use of open dumps is not in line with the increasing public awareness of environmental issues and the demand for environmental improvement, including the current focus on sustainability and global climate change. Closing, or alternatively upgrading, open dumps is therefore a key issue for many communities, particularly in developing countries. Such upgrading is an essential step in reducing future environmental impacts and impacts on public health, as well as avoiding future costs caused by the ongoing waste disposal mismanagement evident at open dumps.

**Impacts**

The impacts from open dumps depend on a number of site-specific factors. The most important factors are the location, waterway, geological / hydrogeological and climatic conditions, together with the, solid waste composition and quantity, the physical extent of the operation and age of the dumpsite.

The following are the most important potential impacts of open dumping on the environment and to public safety and health:

**Environmental Impacts:**

*Surface and groundwater contamination*

Contamination of water may occur when leachate from the dump, via flow paths (on or under the surface), reaches groundwater or surface water. Waste sometimes deposited directly into water at dumpsites resulting in the direct chemical and physical contamination of surface water.

*Soil contamination*

Many contaminants (especially heavy metals are trapped in the soils beneath dumpsites, resulting in risk of further long term environmental contamination and restricting the potential afteruse of the site.

*Air pollution*

Landfilled organic waste may contribute to the greenhouse effect via emissions of methane. Other types of gas emissions may contribute to the degrading of the ozone layer and/or may be toxic to humans (especially scavengers or any local populations).

Uncontrolled burning of solid waste (particularly certain types of plastics) releases smoke and gaseous contaminants into the air. The smoke commonly contains particulates, carbon monoxide and other contaminant gases including low levels of dioxins, all of which can be hazardous to health. In some cases odour and direct hazard may occur from the generation of hydrogen sulphide due to disposal of certain types of waste, or the development of reducing, anaerobic conditions in the waste mass.

*Fauna*

Fauna in and around dumpsites may be impacted either by direct consumption of the solid waste, or by consumption of contaminated plants and/or animals, or as a result of leachate effects on groundwater and surface water.

*Flora*

Plants near open dumpsites can be impacted directly by the waste, dust or smoke from burning.

Dumps tend to affect the type and number of plants in the surrounding area and the presence of dead vegetation is often associated with the zone of direct impact around dumpsites. Dead vegetation is normally a result of trampling by foot, vehicle or animals, but may also be the result of direct contamination by waste or leachate, the migration of landfill gas, or as a result of burning or smoke effects.

**Impacts on Public Health and Safety**

*Open burning of solid waste*

The smoke from burning solid waste can result in respiratory complaints, dizziness, and headaches in the short-term, as well as potentially more serious diseases such as cancers and heart disease in the long term.

*Contaminants in soil and water*

Direct or indirect contact with polluted soil or water by neighbouring water users. Additionally, because of their locations, recovered lands are subsequently cultivated (for vegetables by urban dwellers) which may lead to bioaccumulation of metals which can constitute a health risk.

*Infectious diseases*

One of the primary health risks of dumps is the spreading of diseases (diarrhoea, hepatitis etc.). The ways such infection can be spread are numerous, but are often related to direct contact with the waste (e.g., clinical waste, faecal matter) by scavengers and other unauthorised persons being on the site. The other main pathway is by vectors such as foraging animals, rats, birds, flies and mosquitoes etc).

*Site accidents*

Due to lack of management, site accidents frequently occur at dumpsites, mostly involving scavengers and staff. The greatest risk relates to cuts and wounds (and subsequent infection), but other types of accidents involve fires, explosions, plant and equipment and landslides within the waste mass.

As indicated above, a poorly sited open dump has the potential have a severe impact on the quality of living for the people living near to it and therefore every effort should be made to cease the practice of open dumping, and to instead upgrade progressively to controlled dumping/basic landfilling, and then to sanitary landfilling with a wider ranger of environmental controls.

**Problems Encountered in Closing Open Dumps**

There are many potential problems related to the closing of open dumps. When a decision has been taken to close a dumpsite, several key questions typically arise: what method to use, who is going to pay, and what new waste disposal method to use. Different approaches may be used and the next section gives a general introduction to a suggested common approach.

One problem that always occurs is the difficulty in overcoming old habits and introducing new technology. It is impossible to properly close a site that continues to be used as a dump site. This has to be addressed by providing a new waste disposal facility that can accept the waste and enable the old site to be completely closed, and by informing, training and educating waste generators and site users. Furthermore it is essential to close off access to the existing open dump and enforce the complete closure of the site once any new, upgraded site is available.

Another key problem relates to the cost involved in closing down an old dump. Invariably no money has been set aside for this. However, the long-term costs (including costs related to the impact on the environment and on public safety and health) of not closing down an open dump may far exceed the closure costs. This means that closing open dumps is not primarily a cost issue, although an important one, but an environmental/human health issue. However, in reality many countries with scarce resources have difficulty in raising the required closure costs as other basic infrastructure costs (such as water supply and wastewater treatment) are always prioritized ahead of solid waste issues.

There is also the potential impact on the local economy and income for the scavengers should an alternative source of income be identified (See Key Issue paper on Scavenging).

## Approaches

Different approaches exist for closing down open dumps. If local/national regulation and a solid waste management plan exist, some answers and guidance can usually be found in these. However, it is most likely that it is in the absence of regulatory controls or design guidance that open dumps exist.

The following general approach may be adopted:

√ Investigate impacts

√ Reduce risks (no-cost to medium cost options)

√ Plan new sustainable disposal option

√ Develop a workable financial and information strategy

√ Secure dump users' commitment (using consultation)

√ Choose a closure method ((using risk-based assessment)

√ Choose new waste disposal method (using cost-benefit analysis)

√ Write closure plan

√ Inform, train and educate users

√ Start new facility

√ Close open dump

## Closure Methods

There are in principle 3 methods available to close an open dump:

1. Closing by covering the waste (in-place method)
2. Closing by removing the waste from the site (evacuation/mining method)
3. Closing by upgrading the dump to a controlled dumping site or sanitary landfill (up-grading method)

Which option to use should be based on a study taking into consideration the sustainability and affordability of waste management options in the local context, all the while remaining cognisant of trying to affect real improvement in relation to the actual and potential environmental effects of the dump site.

When choosing a closure/upgrading method it should be borne in mind, that it is not always the most technically advanced solution that is the most appropriate. Depending on the situation, simple improvements of operational aspects (such as applying cover soil and eliminating open burning) can often result in marked site performance and greatly reduced environmental impacts. The key principle should always be to keep things simple and sustainable in a local context, while maximising actual improvement in environmental performance.

**In-place Closure**

This method is the most commonly used option. The solid waste is left at the site and covered with a layer of local soil and re-vegetated. The function of the cover layer is to:

√ Reduce waste exposure to wind and vectors

√ Prevent people and animals from scavenging

√ Control odour

√ Minimise the risk of fires

√ Stop people from using the site

√ Control infiltration of rainwater / surface water

√ Control migration of landfill gas

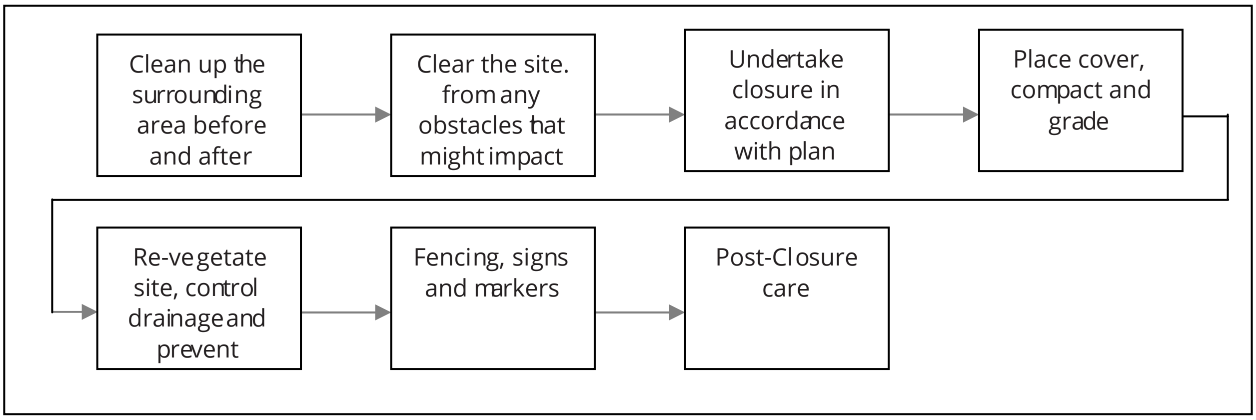
√ Serve as growth medium for vegetation

√ Support suitable post-closure activities

The ability of the cover layer to limit infiltration of water into the dump is an essential environmental protection measure. This is achieved through a suitable combination of cover soil type, thickness, slope and vegetation. In other than very arid conditions a clay cover layer is best suited as it minimises leachate production, and controls landfill gas migration and odour.

The durability of the cap layer and the degree of resistance that the cover offers to infiltration are important design considerations. What constitutes a suitable cap design is site specific and depends on the climate, locally available soil materials and plant types, the extent of protection necessary for the local aquifer and surface water systems etc.

Typical operational steps for in-place closing of an open dump are shown beneath.



In the deciding on a suitable final contour for the closed dump, consideration should to be given to the management of surface water and erosion in the Post- closure period. Post closure care may be defined as requirements placed upon solid waste management facilities after closure to ensure environmental impacts are controlled and public health and safety are adequately maintained, for a specified number of years after closure (typically 20 years may be considered and appropriate period of time for Post-closure care of an open dump).

In the post-closure period there may be regulatory requirements to establish a monitoring programme to assess risks over the long term. The basic principles are to:

- Maintain the Integrity of the Cover layer through regular maintenance to address:
  - Settlement, cap subsidence, slope instability and vegetation cover
  - - Stormwater run-off / run-on drainage controls, and drain and cap erosion
- Operate, Monitor and Maintain
  - Leachate management system (if any)
  - Landfill gas controls and wells (if any)
  - Groundwater wells; stream sampling (if any)

The access to monitoring and control systems of the closed facility should be restricted to authorized personnel only.

**Removing Waste**

With this method the solid waste in the open dump is excavated and disposed off-site (typically to a sanitary landfill, or a waste incineration plant). The removal might be combined with sorting the waste for recovery of recyclables. This may or may not lead to odour issues locally, which will need to be appropriately managed.

The former land use as a waste dump should be noted in land records.

**Closing by Upgrading**

This option may only be feasible if the dump is in an area where ground water pollution is not critical as a dump is not installed with a bottom liner as groundwater protection. This option requires implementation of sound design, operation and management of the landfill at all levels, and is effectively a move towards a sanitary landfill operation.

**Conclusions**

Even though closing of an open dump may pose short term technical or cost difficulty, it is an objective that should be aspired to in all situations. The ongoing operation of open dumps should be discontinued and care taken to close and prevent future contamination from existing sites, according to the principles described in this paper.

It is recognized that there are locations where a lack of resources precludes the immediate closure of open dumps. In these cases a controlled dumping approach where the basic principle is to keep it simple and sustainable without compromising key public health and environmental outcomes is recognize as possibly being appropriate, but this should only be an interim step to proper sanitary landfill practices.

**Further Reading**

ISWA has produced Landfill Operations Guidelines which define good operational practice that can be used when managing all types of landfill from the simple upgrade of an “open dump” through to a fully engineered “sanitary landfill”.

## DUMPSITES & HEALTH

We provide here some indicative recent scientific evidence associating dumpsites with occupational and public human health problems.

**Persistent Organic Pollutants (POPs)**

POPs, such as dioxins and furans (PCDDs and PCDFs), are persistent chemically stable organic compounds. They can be produced in dumpsites through uncontrolled burning waste, natural generation of methane gas and low temperature burning of waste to recover metals[8]. Humans are exposed to POPs through the inhalation, ingestion of contaminated food and absorption through the skin during direct contact with contaminated sources[9].

**Potentially Toxic Elements (PTEs)**

PTEs (some often called 'heavy metals') of public health concern include chemical elements such as lead, mercury, cadmium, arsenic, zinc, chromium, nickel and copper[9]. The PTEs are released into the environment through burning of waste with the aim to recover precious metals. PTEs are also released through other recycling reprocesses occurring on dumpsites receiving E-waste, such as acid leaching of printed circuit boards[10]. Cheng and Hu[11] suggest that mercury (Hg) released into the environment in China could be from batteries and fluorescent tubes disposed with MSW. Lead (Pb), which is one of the most widely distributed PTEs in dumpsites, is released by disposal or burning of lead containing waste such as plastics, rubber and lead treated wood[9].

**Respiratory Disorders**

People working on dumpsites are at risk of developing respiratory diseases from open burning of waste to recover precious metals[12]. In a study conducted in Nigeria, informal waste recyclers reported having developed pneumonia whilst they worked in the dumpsite[13]. Sankoh, Xiangbin and Tran[12], reported that some informal recyclers complained of chest pains. Bacterial upper respiratory tract infections, chronic bronchitis and asthma were found among children living on a dumpsite in Dandora, Kenya[9]. Another study conducted in Delhi India found a prevalence of inflammation of the airways and decreased lung function among dumpsite workers[14].

8 Minh, N. H.;Minh, T. B.;Watanabe, M.;Kunisue, T.;Monirith, I.;Tanabe, S.;Sakai, S.;Subramanian, A.;Sasikumar, K.;Viet, P. H.;Tuyen, B. C.;Tana, T. S.;Prudente, M. S., Open dumping site in Asian developing countries: A potential source of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans. Environmental Science and Technology 37, (8), 2003, 1493-1502p

9 UNEP, Environmental Pollution and Impacts on Public Health:Implications of the Dandora Municipal Dumping Site in Nairobi, Kenya, 2007

10 Song, Q.;Li, J., A systematic review of the human body burden of e-waste exposure in China. Environment International 68, 2014, 82-93p

11 Cheng, H.;Hu, Y., Mercury in municipal solid waste in China and its control: A review. Environmental Science and Technology 46, (2), 2012, 593-605p

12 Sankoh, P. F.;Xiangbin, Y.;Tran, Q., Environmental and Health Impact of Solid Waste Disposal in Developing Countries Cities: A case study of Granville Brook Dumpsite, Freetown, Sierra Leone. Journal of Environmental Protection 4, 2013, 665-670p

13 Afon, A., A survey of operational characteristics, socioeconomic and health effects of scavenging activity in Lagos, Nigeria. Waste Management and Research 30, (7), 2012, 664-671p

14 Ray, M. R.;Roychoudhury, S.;Mukherjee, G.;Roy, S.;Lahiri, T., Respiratory and general health impairments of workers employed in a municipal solid waste disposal at an open landfill site in Delhi. International Journal of Hygiene and Environmental Health 208, (4), 2005, 255-262p

### Diarrhoeal Diseases

Diarrhoeal diseases have been reported amongst waste pickers[15,16]. The problem is exacerbated by the practice of eating food that is collected from the dumpsites (scavenging). The food can be contaminated with waste or has expired. It was reported that children are most vulnerable to diarrhoeal diseases in dumpsites[17]. There was a significant prevalence ofdiarrhoeal diseases amongst children whose mothers lived in the vicinity of a dumpsite in Brazil[18]. Exposure to waste in the environment was found to be the main contributing factor to the high prevalence of diarrhoea amongst children of mothers who work in dumpsites[19]. The children of these mothers were found to be at high risk of diarrhoea, owning to poor personal hygiene of the mothers. Unsanitary food handling practices after being exposed to waste was identified as one of the contributing factors to prevalence on diarrhoeal diseases[9]. Furthermore, a high prevalence of parasitic diseases was found in children in dumpsites[20].

### Adverse Birth Outcomes

A study in Alaska identified an association between low birth weight and pre-term delivery in women who lived in the vicinity of dumpsites[21]. The same study also found an association between intra uterine growth retardation disorders and residence in the proximity of dumpsites. Low birth weight, preterm delivery and congenital malformations were also reported in live births among women who lived in the vicinity of the Love Canal dumpsite in New York[22].

### Cancer (Malignant Tumors)

Comba, et al.[23], conducted a study in the Naples and Caserta Provinces in Italy. The area has had several dumping sites, in which toxic waste were used to be disposed of. There was an elevated prevalence of cancers (cancer of the oesophagus, pleura, stomach, kidney, liver, trachea, bronchus, lung and the bladder) as compared to other regions in Italy. Cancer related deaths were also higher in these two provinces. An increased prevalence of cancers was also observed among occupants of houses built on top of a former dumpsite in Finland[24].

15 Galarpe, V. R. K. R.;Parilla, R. B., Opportunities and threats to adjacent community in a Sanitary Landfill, Philippines, Environment Asia 7, (1), 2014, 112-125p

16 Henry, R. K.;Yongsheng, Z.;Jun, D., Municipal solid waste management challenges in developing countries – Kenyan case study, Waste Management 26, (1), 2006, 92-100p

17 Hunt, C., A review of the health hazards associated with the occupation of waste picking for children, International Journal of Adolescent Medicine and Health 13, (3), 2001, 177-189p

18 Rego, R. F.;Moraes, L. R. S.;Dourado, I., Diarrhoea and garbage disposal in Salvador, Brazil, Transactions of the Royal Society of Tropical Medicine and Hygiene 99, (1), 2005, 48-54p

19 Catapreta, C. A. A.;Heller, L., Association between household solid waste collection and health,Revista Panamericana de Salud Publica/Pan American Journal of Public Health 5, (2), 1999, 88-96p

20 Gómez-Correa, J. A.;Agudelo-Suárez, A. A.;Ronda-Pérez, E., Social conditions and health profile of recyclers from Medellín, Revista de Salud Publica 10, (5), 2008, 706-715p

21 Gilbreath, S.;Kass, P. H., Adverse birth outcomes associated with open dumpsites in Alaska Native villages, American Journal of Epidemiology 164, (6), 2006, 518-528p

22 Austin, A. A.;Fitzgerald, E. F.;Pantea, C. I.;Gensburg, L. J.;Kim, N. K.;Stark, A. D.;Hwang, S. A., Reproductive outcomes among former Love Canal residents, Niagara Falls, New York, Environmental Research 111, (5), 2011, 693-701p

23 Comba, P.;Bianchi, F.;Fazzo, L.;Martina, L.;Menegozzo, M.;Minichilli, F.;Mitis, F.;Musmeci, L.;Pizzuti, R.;Santoro, M.;Trinca, S.;Martuzzi, M.;Bertollini, R.;Carboni, C.;Cossa, L.;De Nardo, P.;Linzalone, N.;Pierini, A.;Lorenzo, E.;Lionetti, E.;Fusco, M.;Scarano, G.;Menegozzo, S.;Doddi, G.;Leonardi, M.;Madeo, L.;Martini, G.;Mazzei, N.;Pizzi, R.;Savarese, A.;Bove, C.;D'Argenzio, A.;Simonetti, A.;Parlato, A.;Peluso, F.;Palombino, R.;Giugliano, F., Cancer mortality in an area of Campania (Italy) characterized by multiple toxic dumping sites, In Annals of the New York Academy of Sciences, 2006, Vol. 1076, 449-461p

24 Pukkala, E.;Pönkä, A., Increased incidence of cancer and asthma in houses built on a former dump area, Environmental Health Perspectives 109, (11), 2001, 1121-1125p

### Occupational Health Risks

Workers at dumpsites are exposed to cuts and abrasions from used syringes, broken glass and other sharp objects[25]. Snake and insect bites have also been reported amongst waste pickers[26]. Back injuries were also reporte[26]. Fungal infections, allergic dermatitis and unspecified pruritis were observed among waste pickers at the Dandora dumpsite[14].

### Consumption of Contaminated Groundwater

An assessment of groundwater was carried out in wells around a dumpsite in Nigeria[27]. Most of the parameters analysed exceeded the WHO standards. The water was used for human consumption. The levels of PTEs (cadmium, chromium, lead, nickel, and zinc) exceeded permissible levels in samples taken around the largest E-waste dumpsite, Alaba, in Nigeria.

25 Akormedi, M.;Asampong, E.;Fobil, J. N., Working conditions and environmental exposures among electronic waste workers in Ghana, International Journal of Occupational and Environmental Health 19, (4), 2013, 278-286.

26 Rendleman, N.;Feldstein, A., Occupational injuries among urban recyclers, Journal of Occupational and Environmental Medicine 39, (7), 1997, 672-675p

27 Ali, A. F.;Young, R. J., An assessment of groundwater contamination around a solid waste disposal site in Kano, Nigeria, WIT Transactions on Ecology and the Environment 180, 2014, 317-323p

## CASE STUDIES

# Agbogbloshie, The Health Impacts

Agboblogshie dumpsite, in Accra Ghana, is one of the largest (10.6 ha[28]) E-waste dumpsite in West Africa receiving around 192,000 tonnes[29] of E-waste every year. It is a vibrant informal settlement with considerable overlap between industrial, commercial, and residential zones. Around 40,000 people live and work in the polluted area of Agboblogshie, where scrap recovering is taking place at numerous small workshops[30].

It has been documented that children, mostly boys work in the Agboblogshie scrap market. Most are between the ages of 11-18, but there are also some as young as 5[31]. The electronic scrap is recovered either with manual dismantling or open burning without any protective means[32]. The interest is placed upon the recovery of copper from cables and valuable metals, such as aluminium from electronics. Both activities are of primary concern from a public health perspective since during the crush or burn of the appliances dusts and fumes, potentially toxic, are released into the air[33,34].

Several researches have shown that scrap recovery activities within Agbogbloshie site have lead to significant health issues among the workers. Workers at Agbogbloshie dumpsites site are exposed to hazardous chemicals such as PAHs, PBDEs, BFRs and heavy metals. Researchers have found elevated Fe, Sb, and Pb concentrations in urine of E-waste recycling workers in Accra[30]. Other reports have showed that E-Waste recyclers at the area suffers from chest pain due to fly ash inhalation[33], burns from open fires, cut and catarrh[35] from dismantling and smoke, and Nausea/vomiting[30] from odours. Furthermore, other reported health issues at the area are headaches, breathing difficulties, diabetes, cancer, heart, liver, lung and kidney diseases, as well as brain swelling and muscular atrophy, due to heavy metals and phthalates inhalation[36].

Disposal of E-Waste at the site has also lead to significant soil and water contamination at the surrounding area. Soil samples taken from around the perimeter of Agbogbloshie dumpsite from Greenpeace have shown that numerous hazardous chemicals and toxic metals are present in the soils around the site. In some cases certain metals were present at the samples at concentrations over one hundred times higher than typical background levels for soils, including the highly toxic metal lead[37]. Contamination with other toxic metals, such as cadmium and antimony, has also been detected. There concentrations have been found 12 times above the limit[35].

28 D-Waste estimation

29 Romain David, Les 10 sites les plus pollués du monde, Le Figaro, 7 November 2013, Available at: http://www.lefigaro.fr/sciences/2013/11/06/01008-20131106ARTFIG00623-les-10-sites-les-plus-pollues-du-monde.php (accessed on 28th July 2014)

30 Feldt, Torsten, Julius N. Fobil, Jurgen Wittsiepe, Michael Wilhelm, Holger Till, Alexander Zoufaly, Gerd Burchard, and Thomas Goen. 2013. High levels of PAH-metabolites in urine of e-waste recycling workers from Agbogbloshie, Ghana, Science of the Total Environment 466-467, 1 (January): 369-376.

31 Greenepeace, Poisoning the Poor. Electronic Waste in Ghana, 2008, Available at: http://www.greenpeace.org/denmark/Global/denmark/p2/other/report/2008/poisoning-the-poor-electroni.pdf (accessed on 1st August 2014)

32 Kwadwo Ansong Asante, Tetsuro Agusa , Charles Augustus Biney , William Atuobi Agyekum, Mohammed Bello, Masanari Otsuka , Takaaki Itai , Shin Takahashi , Shinsuke Tanabe, Multi-trace element levels and arsenic speciation in urine of e-waste recycling workers from Agbogbloshie, Accra in Ghana, Science of the Total Environment 424, 2012, 63–73p.

33 Takaaki Itai , Masanari Otsuka, Kwadwo Ansong Asante, Mamoru Mutoa,Yaw Opoku-Ankomahb, Osmund Duodu Ansa-Asare , Shinsuke Tanabe, Variation and distribution of metals and metalloids in soil/ash mixtures from Agbogbloshie e-waste recycling site in Accra, Ghana, Science of the Total Environment 470–471, 2014, 707–716p

34 Blacksmith Institute, Top Ten Toxic Threats in 2013, Agbogbloshie, Ghana, Available at http://www.worstpolluted.org/projects_reports/display/107#_1 (accessed on 1st August 2014)

35 Martin Oteng-Ababio, Economic Boom or Environmental Doom: E-waste Scavenging as a Livelihood Strategy among the Youth in Accra, Ghana, ECAS 2011- 4TH European Conference on African Studies Uppsala 15-18 June 2011, University of Ghana, Department of Geography and Resource Development

36 Jörg Becker, Computers and ecology, WACC-Global, Media Development 2/2009, Available at http://cdn.agilitycms.com/wacc-global/Images/Galleries/RESOURCES/MD/MD_ARCHIVES_COVERS/MD_pdfs/MD-2009-2.pdf#page=37 (accessed on 28th July 2014)

37 Jack Caravanos, Edith Clark,Richard Fuller, Calah Lambertson, Assessing Worker and Environmental Chemical Exposure Risks at an e-Waste Recycling and Disposal Site in Accra, Ghana, Journal of Health and Pollution, Vol. 1, No. 1,Febuary 2011,16-25p

Moreover, samples taken from nearby surface and ground waters have indicated water contamination by the so-called phthalates, which often are used as softeners for plastics like PVC[35,] and by strontium (Sr) which is primary used in glass of color television cathode ray tubes[38]. High levels of PBDEs and PCBs, related to E-Waste processing, have been observed in Weija Lake, Volta Lake Benya and Keta Lagoons[39].

Finally, lead, copper and iron have been detected in the ambient air. Lead concentration has been over 4 times the permissible USEPA ambient air quality[37], while no international standards exist for copper and iron in ambient air.

**Figure 4:** Adam Nasara, 25, uses Styropor, an insulating material from refrigerators, to light a fire[40]

38 Wikipedia, Strontium, 24 Jule 2014, Available at: http://en.wikipedia.org/wiki/Strontium (accessed on 28th July 2014)

39Kwadwo Ansong Asante, Shin Takahashi , Takaaki Itai , Tomohiko Isobe,,Gnanasekaran Devanathan, Mamoru Muto, Seth Koranteng Agyakwah,Sam Adu-Kumi, Annamalai Subramanian, Shinsuke Tanabe, Occurrence of halogenated contaminants in inland and coastal fish from Ghana: Levels, dietary exposure assessment and human health implications, Ecotoxicology and Environmental Safety 94, 2013, 123–130p

40 Photographer Kevin McElvaney, Agbogbloshie: the world's largest e-waste dump – in pictures, The Guardian, Available at http://www.theguardian.com/environment/gallery/2014/feb/27/agbogbloshie-worlds-largest-e-waste-dump-in-pictures (accessed on 28th August 2014)

# Bantar Gebang, An Informal Recycling Habit

Bantar Gebang dumpsite is a characteristic example of a dumpsite that hosts a significant number of waste pickers. The site is located 40 km away from central Jakarta, within Bekasi Municipality of the West Java Province and is operational since 1988. Currently, there are around 5,000 waste pickers working on the site on a daily basis, while almost 1,534[41] scavenger households have been established around it.

**Structure of the Informal Recycling Sector in Bantar Gebang**

Waste pickers of Bantar Gebang are well organized in at least 8 types of recycling actors which are:

1. The big boss, who actually is the boss of the waste pickers and employ “live-in” and “live out” waste pickers for recyclables collection;
2. the small boss, who employs small number of “live-in” and “live out” waste pickers for recyclables collection and a small number of independent waste pickers;
3. the big middleman;
4. the small middleman;
5. the live-in waste picker, who live in the residence provided by a boss;
6. the live-out waste picker, who do not live in the residence provided by a boss;
7. the independent waste picker, who do not serve for a specific big boss or a small boss, and
8. the daily worker, who is a part-time worker

Independent waste pickers and daily workers, depend on temporary employer-employee relationships. All big bosses and big middlemen have built direct connections with recycling factories, and the community of scavengers in the site recognized them as big bosses and big middlemen due to the connections[41].

**Types of Recyclables Collected**

A variety of recyclables are collected by the waste pickers of Bantar Gebang: plastics, iron, glass, aluminum, rubber, bones, carpets, copper, wood, mixed paper, spoons, forks, cds/dvds etc. Some of these recyclables have specific terminology used inside the community of scavengers and classified according to their characteristics. For example, plastic bags are further classified into AD/HD/Kresek, PEE, PP and Sablon based on their senses of sight and touch. Also, there are differences in names depending on the origin of the scavenger. For example, Ember and Mainan are the same plastic materials but waste pickers call them by different local names[41].

41 Shunsuke Sasaki, Tetsuya Araki, Employer- employee and buyer-seller relationships among waste pickers at final disposal site in informal recycling: The case of Bantar Gebang in Indonesia, Habitat International 40, 201, 51-57p

**Processing Activities**

Bantar Gebang waste pickers activities have been well documented regarding the recyclables processing steps which are described as follows[41]:

1. Collection. This step takes place on the site by waste pickers. Wheeling. The recyclables are transported by carts to the slums surrounding the site.
2. Wheeling. The recyclables are transported by carts to the slums surrounding the site.
3. Sorting. It takes place either on site by or after the recyclables are transported to the slums.
4. Processing. Shorted recyclables are then processed to gain different type of materials. For instance, sandals are cut by knife to separate the soles from other parts made from different materials.
5. Packaging. Processed recyclables are packaged with different ways according to their types.
6. Transportation by trucks to recycling factories under the control of big boss of waste pickers or big middlemen.

When the transaction of the recyclables is taking place on site, the recyclables are sorted and processed before selling at the big boss of waste pickers or big middlemen. If the recyclables are transported by carts to the slums surrounding the site they are either sold directly before processing, or sorted and processed in the slum and then transferred by trucks to recycling factories with trucks under the control of big boss or big middlemen[41].

The transaction among waste pickers and their bosses is occurred by weighting the recyclables. The waste picker and a representative of the employer weight the recyclables on a scales and the weigh is read aloud and is recorded in a notebook. Based on these records the employer pay slips to the waste picker[42].

**Figure 5:** Pickers fill baskets with the items they salvage[43]

42 Shunsuke Sasaki, Tetsuya Araki, Armansyah Halomoan Tambunanb, Heru Prasadja, Household income, living and working conditions of dumpsite waste pickers in Bantar Gebang: Toward integrated waste management in Indonesia, Resources, Conservation and Recycling 89, 2014, 11–21p

43 Photographer Mark Tipple, Socialphy Beta, 7 Communities Who Salvage Trash to Survive, Available at: http://www.socialphy.com/posts/off-topic/13374/7-Communities-Who-Salvage-Trash-to-Survive.html (accessed on 28th July 2014)

# Dandora, An Environmental Disaster

The Dandora municipal waste dumping site, located to the East of Nairobi, has been reported in 2007 as the thirty worst polluted places on earth, were municipal waste is the main reason of pollution[44].

The site which is operational since 1975 is the only waste disposal option for Nairobi and nowadays receives 730,000 tonnes of MSW annually[45]. It is about 8 kilometers away from the city centre and occupies an area of over 53 ha. Dandora dumpsite is adjacent to Korogocho slums, the fourth largest slum in Nairobi with a population of about 120,000 inhabitants. The site also affects Dandora, Kariobangi and Baba Dogo residential areas with a total population of about 900,000 inhabitants[46].

The Nairobi River passes besides the dumpsite. Some of the waste ends up in the river, extending environmental and health risks to thousands of people living within the vicinit[46].

UNEP conducted a study[45] for measuring the environmental impacts of Dandora dumpsite in soil and Nairobi's River. This pilot study has linked environmental pollution to public health. Soil samples analyzed from locations adjacent and within the dumpsite showed high levels of heavy metals emanating from the site in particular lead, mercury, cadmium, copper and chromium.

Mercury concentration in soil samples greatly exceeded the WHO acceptable exposure level of 2 ppm, cadmium (Cd) adjacent to the site; eight times higher than those prescribed by the Dutch and Taiwanese authorities (5 ppm). Copper concentrations were greatly exceeded the prescribed standard values and the natural range (7 and 80 ppm)[45].

For example, about 50% of children examined who live and school near the dumpsite had respiratory ailments and blood lead levels equal to or exceeding internationally accepted toxic levels (10 μg/dl of blood), while 30% had size and staining abnormalities of their red blood cells, confirming high exposure to heavy metal poisoning[45].

**Figure 6:** Waste picker crossing Nairobi River to reach the neighboring[47]

44 ETHZ Studio Basel Contemporary City Institute, The Waste Network, Available at http://www.studio-basel.com/assets/files/files/029_NRB_04_waste.pdf (accessed on 30th July 2014)

45 UNEP, Environmental Pollution and Impacts on Public Health: Implications of the Dandora Municipal Dumping Site in Nairobi, Kenya, Available at: http://www.unep.org/urban_environment/pdfs/dandorawastedump-reportsummary.pdf (accessed on 30th July 2014) Oluoch Japheth

46 Ogola and Fr Daniel Moschetti, Dandora Dumpsite: Struggling for health, security and dignity

47 Micah Albert, Kenya: The Pickers of Dandora, Pulitzer Center On Crisis Reporting, April 20, 2012, Available at http://pulitzercenter.org/reporting/pickers-dandora-garbage-dumpsite-nairobi-kenya (accessed on 30th July 2014)

# Estrutural, The Biggest Active Dumpsite in Brazil

Estrutural dumpsite is the biggest active waste disposal site in Brazil occupying an area of 136 ha[28]. The site is located just 15 km from the capital city of Brazil, Brasília, and has been active for more than 50 years. The waste in place is around 21 to 30 million tonnes[28] and reaches a height of 60 meters[48]. In 2013 the site received 2,000,000 tones[48] of waste, while currently Estructural dumpsite receives 2,700 tonnes of municipal waste and 4,000 tonnes of C&D waste daily[49].

### The Informal Sector

2,700 waste pickers, many of them organized in cooperatives, live and work[49] in Estructural dumpsite making their monthly income by collecting recyclable materials. Around 3% of the disposed waste is recovered by Estructural's waste informal sector. Waste pickers work in precarious situation with only few types of equipment, such as balers[49].

Although authorities have prohibited child work on the dumpsite since 2011, it is still very common to find children and teenagers working on the site[48].

### Accidents

Many accidents and deaths have been reported within the dumpsite. In 2013, a wagon passed over the leg of a scavenger[48], while in April 2014, a man was hit by a tractor during the night and died. The most recent accident was occurred in July 15th, when a 22-year-old man was hit by a truck transferred to the hospital[50].

### Environmental & Health Impacts

Environmental impacts resulted from the operation of the site is of great concern, especially due the fact that the site is located only 0.5 Km from National Park of Brasília which supplies Brasília with 27% of its drinking water[51]. In case the dumpsite leachate reaches the nearby lake, it can compromise the use of the water and put at risk the public health.

Proliferation of exotic vegetal and animal species has been reported in the Park, close to the dumpsite's borders. Animals such as vultures, rats, cockroaches and dogs found on the dumpsite hunt other species and spread diseases, disturbing the original wildlife.

The Public Ministry of Brazil, which is responsible for the protection of the National Park of Brasília , has given a 5 million US$ fine to the municipality responsible for the operation of the dumpsite and has been trying to close it since 2005[49].

**Figure 7:** Waste picker who lives in Estrutural Dumpsite[52]

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# Leuwigajah, Dumpsites & Fatal Accidents

Leuwigajah dumpsite was one of the largest waste disposal sites in West Java Province, in Indonesia operating between 1987 and 2005. The site received 4,500 tonnes of MSW per day[53] from Bandung City, Cimahi City and Bandung Regency on a 25.1 ha area[54]. Established on a valley, it has been hosting almost 600 waste pickers, shorting recyclables[55].

In February 2005, Leuwigajah dumpsite collapsed. Almost 2.7 millon cubic meters of waste went down hitting a settlement close by, destroying at least 69 houses[56], and killing 147 people[53]. This was not the first time that a waste landslide had taken place at Leuwigajah dumpsite. The site had already experienced one waste landslide in 1987 and another in 1990. After the second landslide in 1990, the site was characterized as unsuitable for disposal. However the local authorities continued its use since there were no other disposal options.

The fatal accident in 2005 took place after three days of heavily rainfall[57]. Waste split down to the valley, covering a distance of 950 meters and an area of 75 ha[54]. Rescue works, which lasted 3 weeks, were massively hindered by landfill fires. Unfortunately, no survivors were found[53]. After the accident, the dumpsite was shut down. The City of Bandung has then faced a major problem managing its waste and the entire city has been turned into a disposal site (Kota Sampah)[58].

The landslide has also been linked to a number of environmental problems, such as odours, air pollution from the landfill fires, occurred after the accident, and surface water contamination; leachate reached Waduk Sagling Dam Lake which is used for drinking water and canals which are utilized in agriculture and industry[54].

**Figure 8:** Slope crest of Leuwigajah dumpsite[59]

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# ANNEX V

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