Rev. Est. de Políticas Públicas, 3(2): junio - noviembre 2017, 33-39
http://dx.doi.org/10.5354/0719-6296.2017.46351
ISSN edición web: 0719-6296

Biogas production from municipal waste in Rio de Janeiro: either the solution and the problem

Anaide Ferraço

Leiden University

Resumen

With the current consensus about the need to decarbonise the energy system to decrease its GHG emissions in order to mitigate global warming, biogas has been growing worldwide as a low carbon energy alternative. Biogas originates from the biological breakdown of organic materials. This process happens in landfill sites when organic waste decomposes and produces what is known as landfill gas. In compliance with the Brazilian National Policy on Solid Waste, in 2012 Jardim Gramacho landfill, was closed, leaving a poll of 1,700 scavengers without their livelihood. De dump was not only important for those workers but also for approximately 12,000 inhabitants depending directly or indirectly from the waste picking activities. After de closure, a biogas plant was built on the site to collect and process methane originated in the old dump. This enterprise presented environmental improvements to the region. However, the residents who worked on the selection of recycling materials were left without a source of income. Up to now not enough public policies were implemented to ensure livelihood improvements to the waste pickers and inhabitants of Jardim Gramacho district.

Palabras clave: Biogas, waste pickers, public policies.

Producción de biogás desde residuos urbanos en Rio de Janeiro: ya sea la solución o el problema

Abstract

Con el consenso actual sobre la necesidad de descarbonizar el sistema energético para disminuir sus emisiones de GEI para mitigar el calentamiento global, el biogás ha crecido en todo el mundo como una alternativa energética de bajo carbono. El biogás se origina en la descomposición biológica de materiales orgánicos. Este proceso ocurre en los vertederos cuando los desechos orgánicos se descomponen y producen lo que se conoce como gas de vertedero. En cumplimiento de la Política Nacional Brasileña de Residuos Sólidos, en 2012 se cerró el vertedero Jardim Gramacho, dejando aproximadamente a 1.700 hurgadores de basura sin su sustento. El vertedero no sólo era importante para esos trabajadores, sino también para aproximadamente unos 12.000 habitantes que dependían directa o indirectamente de las actividades de recolección de residuos. Después del cierre se construyó una planta de biogás en el sitio para recolectar y procesar el metano originado en el antiguo vertedero. Esta empresa presentó mejoras ambientales en la región. Sin embargo, los residentes que trabajaban con la selección de materiales de reciclaje se quedaron sin una fuente de ingresos. Hasta el momento no se han implementado políticas públicas suficientes para asegurar la mejora de los medios de subsistencia de los recicladores y habitantes del distrito de Jardim Gramacho.

Keywords: Biogás, recicladores, políticas públicas.

***Dirección de correspondencia [Correspondence address]:** Anaide Ferraço, Leiden University
E-mail: annaferrazzo@hotmail.com

Fecha recepción: 12 de septiembre 2017 **Fecha aceptación**: 12 de noviembre 2017

Introduction

Currently news about climate change have been updated every day. According to scientists and government officials, we are experiencing climate change due to the great anthropogenic greenhouse gas emissions in the atmosphere. In many countries, public policies have been implemented to reduce environmental degradation and thereby mitigate emissions of polluting gases. The most developed countries already have the technology to turn urban solid wastes into biogas. Projects of this nature not only allow the generation of clean and renewable energy, but also a suitable destination for the enormous amount of garbage produced in large cities. The case of the Gramacho landfill in the city of Duque de Caxias, Brazil, which has been transformed into a biogas plant, is an example policy to meet the international agreements for the mitigation of climate change. The present study aims to demonstrate the benefits that such a policy to a country like Brazil but at the same time the precautions needed before the implementation of this kind of policy so that the solution to a problem will not become the cause of another critical one.

The first part of the article demonstrates the importance of giving a purpose to urban solid waste related to the greenhouse gases emissions mitigation policies. The second part provides a history of Jardim Gramachos' dump, from its beginning to its closure. The third and final part of the study deals with the solutions presented before the implementation of closure policy and the results of this policy for the community of waste pickers who worked on the dumpsite and also for the inhabitants in the region. Finally, a conclusion is presented on the implementation of policies for the mitigation of climate change and the results of them for the impoverished population in a developing country such as Brazil.

Waste to energy: current and future possibility

In the last decade, many researchers have stressed the challenge of the transition to sustainable low carbon economy (Elzen *et al.*, 2004; Smith *et al.*, 2005; Grin *et al.*, 2010). A variety of low carbon technologies for supplying energy are required to keep economic growth without degrading the environment. In December 2015, the 21th Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) took place when a new international agreement was made to carry out initiatives worldwide for combating the effects of climate change. The main goal is to reduce the rise in global temperature by reducing anthropogenic CO2 emissions. However not only carbon dioxide (C02) accounts for the greenhouse gas effect. Methane is also a prevalent greenhouse gas emitted by human activities. Frequently, carbon footprint calculations only measures CO2 emissions while methane can cause stronger greenhouse effect than carbon dioxide. Methane is the primary component of natural gas and its emissions to the atmosphere accounts for an import deal of global warming. Nevertheless, methane is a valuable fuel source, as its burn is cleaner than coal or oil.

Methane is also the primary component of biogas or biomethane. Biogas is produced by biological processes of anaerobic digestion of organic material from agricultural and industrial residues, as well as municipal waste. Anaerobic Digestion plants work at low temperatures allowing micro-organisms to digest the raw material in a controlled reactor in the absence of oxygen to produce biogas. This process happens also in landfill sites when organic waste decomposes and produces what is known as landfill gas which can a be tapped to generate energy. Instead of going to dumps and other destinations without proper use, solid waste can be converted into energy which is fundamental to alleviate global warming and groundwater contamination.

> "Methane is a short-lived climate pollutant with significant warming potential, and over a 20-year period, one ton of methane causes 72 times more warming than one ton of carbon dioxide (CO2). The mitigation of methane from existing landfills provides important climate benefits"
>
> (Pierson, 2013).

Natural gas is identified as fossil fuel, while biomethane is a renewable and clean source of energy. Production of fossil fuel derived methane depends on the natural reserves which vary by country and is a finite resource. Biomethane instead, is a renewable source of energy that can be produced worldwide. Because of the widespread consensus about the urgency in decarbonising the energy system to mitigate its GHG emissions, biogas has been widely growing as a low carbon energy source (Stern, 2017).

The European countries have currently around 12,000 biogas plants operating, most of them being agricultural cogeneration heat and power plants. "177 of these are biomethane plants, where biogas is upgraded to a quality similar to natural gas. 128 of

these plants inject biomethane into the natural gas grid, especially in Germany, Switzerland, the Netherlands and Austria" (EurObserv, 2015 in Stern, 2017: 11).

Germany has been the front runner in the development of biogas technology and with a leading position in the European biogas market. Regarding to overall biogas production, Germany is followed by the United Kingdom, France, Italy and the Netherlands. In 2013, primary production of biogas in Europe, with landfill and sewage gas included, was an estimated 13.4 Mtoe[1] (Hijazi *et al.*, 2016).

In the United States, landfills are the 3rd largest source of methane by human activities. According to the U.S. Environmental Protection Agency (EPA), landfill gas accounts for 17.7 percent of all U.S. methane emissions. To stimulate landfill managers and development partners to capture landfill gas, EPA created in 1994, the Landfill Methane Outreach Program. By October 2012, there were 605 active energy projects in 48 states. The operational landfills together, produce annually, around 15 billion kilowatt hours of electricity and 100 billion cubic feet of Landfill gas for direct use (Pierson, 2013).

Brazil generated daily in 2016, approximately 214,5 thousand tons of solid urban waste, which is equivalent to about 78,3 million tons per year. The waste collect coverage rate in the same year was 91 %, this means that around 7 million tons of waste goes to inappropriate destination (A Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais, 2016). Moreover, 58.4 % of the collected waste went to sanitary landfills while 41,6 %, that is 29,6 million tons of waste were disposed in controlled dumpsites or dumps, which do not have the set of systems and measures necessary to protect the environment against damage and degradation.

These figures prove that Brazil has the potential to generate great amount of biogas from municipal solid waste. Converting waste into energy would not only add to the energy system but also reduce pollution, greenhouse gases emissions, as well as to the preservation of ground and surface water, recovery of degraded areas and creation of jobs. Nevertheless, there is a lack of investments and interest from the government to make progress and promote biogas generation from urban waste even though Brazil already has public policies for this purpose, such as the National and State Policies for Solid Waste.

Despite the established public policies and the technical feasibility of the use of biogas from landfills, there are still few initiatives in this regard in Brazil, contrary to what has been observed in other countries. The final disposal of urban solid waste has been a major challenge in recent years. Regardless of legal determinations and efforts undertaken, the inadequate disposal of solid waste is still very present in all states of Brazil.

According to the National Overview of Solid waste (2016) from Abrelpe (Brazilian Association of Public Cleaning and Special Waste Companies), were collected in the state of Rio de Janeiro, 21,474 tons per day of municipal solid waste, but only 68,4 %, equivalent to 14,688 tons daily were disposed in sanitary landfills. In Rio de Janeiro city alone, l2,147 tons of solid urban waste were discard in open dumps each day in the past year. Another 4,638 tons were discarded in controlled dumps, where there is some environmental care but also considered inadequate.

The case of Jardim Gramacho landfill

Jardim Gramacho, one of the world's largest open dump, located on a mangrove area on the edge of Guanabara Bay in Duque de Caxias city, the metropolitan region of Rio de Janeiro, started its activities in 1973 after the Institute of Colonization and Agrarian Reform (INCRA) signed a contract with the Foundation for Development of the Metropolitan Region (FUNDREM) and the Urban Cleaning Company of Rio de Janeiro (COMLURB), making a parcel of land nearby the Guanabara bay available for the implementation of a garbage dump. The agreement for the implementation of the dump was done in an incorrect and unconstitutional way since mangrove trees, abundant in the area, are under permanent protection by the Brazilian Forest Code. Compounding the scenario of ecological degradation, the granted lot turned into dump is bordered by two rivers: Iguaçu and Sarapuí. This proximity to the rivers brought another constitutional problem with the National Environment Council (CONAMA) which prohibits the release of waste into water courses and its immediate surroundings. As the volume of dumped solid waste increased, the occupied area advanced both towards land and sea, and so percolated liquids consolidated as one of the great polluters of the Guanabara Bay (Sousa, 2017).

Since its establishment, the surroundings of Jardim Gramacho dump grew into a city of waste pickers that found in the junk heap their source of income. Over time, garbage beyond municipal solid

[1] Million tons of oil equivalents.

waste was dumped onto the site, including industrial and hospital waste from seven different municipalities. For more than twenty years before some changes were made, there was no policy to prevent environmental and social problems allowing people, including children to work in the area. There was no separation between toxic waste and general waste, which created a place extremely unhealthy and prone to contamination and disease transmission to people and animals.

Brazil's opening to foreign capital in the 1990s led the country to restructuring its production through industrial automation and outsourcing, increasing the rate of unemployment. Faced such a situation, a portion of the unemployed found their livelihood in the informal labour market, and one of the options was waste picking, regardless its poor working conditions, low wages and lack of labour rights. Entry the informality and staying in it happened specially because of the lack of qualification of the unemployed. Allied to this, the low level of education prevented even more this population from reinserting into the formal market.

According to the National Movement of Collectors of Recyclable Materials - MNCR and also from IPEA (Research Institute of Applied Economic) there were in 2013 between 400 to 800 thousand individuals working in informality as waste pickers throughout the country. Mattos argues that "the way they are identified carries with it a heavy burden of stigmatization. Their living conditions reveals an enormous demand of specific public policies to address their most urgent needs" (2016: 2).

In 2004, 1.700 waste pickers were registered working at Jardim Gramacho dump. The affordable activity to any individual who was willing to work on it and the large quantity of solid waste bought to the dump, were significant reasons for the increasing number of waste pickers. In its last decade of operation, the dump received eight thousand tons of waste daily, and the recyclable material extracted by these workers reached the approximate number of 200 in one day only.

The Brazilian Institute of Social and Economic Analyses (IBASE) reported that in 2005 Jardim Gramacho area had approximately 20,000 inhabitants with around 60 % of them depending directly or indirectly from economic activities related to waste picking. 'Lack of institutional, financial and technical support coupled with deficient public policies from the municipalities involved, made not only the dumpsite but also its surroundings, a degraded region with serious socio-environmental" (Xerez, 2013: 22).

After more than three decades of operation, Jardin Gramacho's gradual closure began in April 2011 and it was effectively shut down on June 6th, 2012. Around two thousand collectors were left without their main source of income. The closure impacted not only the life of these workers, but the whole neighbourhood that depended on the savings generated from the collection of recyclable materials. At that time, the people who worked there for years had several concerns especially regarding to the lack of professional training to take on new jobs and the scarcity of opportunities in the labour market.

Jardim Gramacho is a nationally known neighbourhood mainly because its social and environmental issues, mostly because the deposit of waste in the area during 34 years. These conditions still persist after the closure of the dump, as most people in the community don't have a new source of income. Due to the absence of effective public policies for the social integration of former waste pickers, the local housing conditions are very poor, and there is a lack of piped water supply, medical care and public safety.

On the other hand, Duque de Caxias is one of the largest cities of Rio de Janeiro state both in population and wealth. The municipality is Brazil's 10th largest city in terms of gross domestic product (GDP) and the 2nd largest in the state of Rio de Janeiro, due to exports, including oil and its derivatives. One of the largest refineries of the partially state-owned company, Petrobras, is located in the city, being part of it, a gas-chemical pole and a thermal power plant. In contrast, Duque de Caxias occupies 49th position in the ranking of the Human Development Index (HDI) in Rio de Janeiro state[2]. Duque de Caxias has one of the worst income distributions and is an example of Brazil's inequality paradox.

The first activities at Jardim Gramacho dump, back in the 1970s, solid waste was left in open air, without prior assessment, soil preparation or system for treating fluids generated by the decomposition of garbage. In 1996, influenced by the discussions held at ECO-92[3], COMLURB and other municipalities in the region turned the"Caxias Dumpïnto a controlled landfill. Up to its closure in 2012 the waste was controlled and periodically covered with clay and grass, in addition to leachate and gas catchment. In 2004, COMLURB started working with different advisors and NGOs including the World Bank and the United Nations on a proposal to completely close the landfill for biogas

[2]Data from the United Nations Development Program (2010).

[3]United Nations Conference on Environment and Development- Earth Summit, Rio de Janeiro, 1992.

waste-to-energy operations. The contractual agreement for the Gramacho Landfill Gas Project was made in 2007 between COMLURB and Novo Gramacho Energia Ambiental SA, winner of the public bid and responsible for managing the landfill closure, biogas waste-to-energy construction, and further neighbourhood monitoring, for 20 years after closure.

In a pioneering initiative supported by Petrobras, Gas Verde SA, subsidiary of Novo Gramacho Energia Ambiental SA, built a plant with a production capacity of 70 million m3 of biogas per year. The biogas plant purifies the methane gas produced by trash decomposition that lingers in the area for years, into clean, usable bio-methane gas. To execute this project, Gas Verde SA took out a $48.6 million loan from the Export-Import Bank of the United States. The energy generated from the garbage accumulated for decades in Gramacho Landfill would supply Petrobras refinery of Duque de Caxias (Reduc). It is the first time that a refinery runs on renewable gas in Brazil.

Jardim Gramacho plant's production will directly replace as estimated 10 % of the natural gas derived from fossil-fuel sources that is consumed by Petrobras' refinery (BViP). The biogas collected at the landfill, is purified until it reaches the quality standard required by the Petrobras technical specifications. The end product is then transported through an exclusive built six kilometres pipeline to the Reduc installations (Petrobras).

Gramacho's gas plant was built with imported technology from the United Sates as Brazil do not have the required technological advances. In 2012, FirmGreen and other U.S. green-technology suppliers benefited from the transaction with the exports of equipment and services. Seen as the world's largest biogas project of its type, it was estimated that this project would directly generate 165 new jobs at its facilities and at other companies in seven different American states (FirmGreen, 2013).

When a solution becomes a problem

Dumps and controlled landfills in Brazil attract a large number of individuals because of the abundant availability of recyclable waste (such as paper, plastic and metals) that are collected during hard working hours, to be exchanged for small money at intermediate recycling depot. This activity consolidates a disorderly urban sprawl, with severe restrictions on social rights, including basic sanitation, which is a right guaranteed by the Brazilian Constitution and defined by Law no. 11.445 / 2007 as the set of services, infrastructure and operational facilities for water supply, sewage, urban cleaning, urban drainage, solid waste and rainwater management.

> "Gramacho's landfill is perhaps the clearest example of the fragility of the urban solid waste management system in Brazil and the authorities' disregard for planning and urban space creation. Around the dump large pockets of misery were formed by a population dependent on the waste picking activity, living in insalubrity work and housing conditions"
>
> (Becker Lins, 2016).

During the planning, launch and agreement signature of the gas project, before the dump's closure, government and private companies, elaborated, presented and promised a number of measures that would improve work, housing and living conditions of the scavengers in the region as well as environmental recovery of degraded areas.

The environment minister Carlos Minc declared "we are transforming greenhouse gas into renewable energy and creating resources for the municipalities of Rio de Janeiro and Duque de Caxias for the recovery of the mangrove near Guanabara Bay and for the waste pickers' associations" (Ministério do Meio Ambiente, 2010). According to the Ministry for the Environment part of the revenue from the biogas sale would be used to create a social fund to assist garbage scavengers with training programs to facilitate their entrance into the formal labour market (Ministério do Meio Ambiente, 2010).

Gas Verde SA has published on its website the company's its goals for Gramacho biogas project which are: cleaning of the area affected by the old dump, environmental recovery of the region and elimination of the waste slurry disposal in Guanabara Bay. In the social scope, the company is committed to carry out citizenship development campaign, training program and cooperative start for the community of waste pikers.

Although improvements have been made in the region, the initial planning needs to be revised and mostly modified since Jardim Gramacho community witnesses a different reality since the dump's closure.

According to Diogo Arantes, environmental engineer and coordinator of Novo Gramacho Energia Ambiental;

> "It was mistake to stop scavengers' work, instead they should have received guidance to be inserted in the labour market. An illusory calculation was made of how much money a waste picker would need for a 15 years livelihood and equivalent resources was given to them. They received compensation rather than preparation. In fact, we gave money to people who would not know how to use it"
>
> (Ribeiro, 2014).

Sousa states that:

> "The closure of dump left a huge environmental and social liability. A range of promises and commitments from the state and federal governments made to the waste pickers and residents of Jardim Gramacho were not fulfilled: regeneration of the mangrove areas, revitalization and infrastructure of the neighbourhood and implementation of professional qualification and training programs, among other promises. A single commitment was fulfilled: each of the 1,700 registered waste pickers received an indemnity of R$ 14.000 and nothing else"
>
> (Sousa, 2017).

The landfill closure policy included not only the removal of waste pickers from the region and measures to mitigate the impact of waste on the mangrove nearby but also a wide program of skills training, application of indemnities and unemployment insurance grants for all registered scavengers. However, the inclusion policies were not complete implemented and the residents' association, before very operative, started losing its strength as the scavengers begun to leave the neighbourhood (TETO, 2014).

The education level in the region shows why many people were unable to obtain formal jobs after the closure of the dump. According to the research conducted by TETO[4] in the neighbourhood in 2013, only 2.4 % of households, older than 25 years old, completed high school (in the city of Rio de Janeiro city the rate is 53.7 %). And the future is not very promising since among Jardim Gramacho's young generation (5-24 years old), 40 % of still do not attend an educational institution.

Data from the same research show that housing conditions are extremely precarious, with 91.6 % of households living in homes predominantly made with wood pieces and low constructive quality, and therefore very unstable, putting its inhabitants at risk. 93 % of the houses have irregular electrical connections, 74 % have no running water and 26 % have no toilet. The population is significantly vulnerable to respiratory diseases (especially young children) due to humidity in their homes since many houses have earth floor and very often a lack on the roof. The region suffers from constant flooding due to the silting of rivers in the surroundings caused by the expansion of the dwellings during the operation of the landfill and because it is a floodplain area at sea level.

Tião Santos, president of the Association of Metropolitan Waste Pickers of Jardim Gramacho in Rio de Janeiro (ACAMJG) declares:

> "What you see in the vast majority of municipalities and state government is"let's close", having this as a solution. So, although the policy treats solid waste as a common good, job and income opportunity and social inclusion, it ends up being a policy of exclusion of the exclusion, before the dump is closed, promises are made but, after the closure, everything falls into oblivion and the population is abandoned, as is the case in Jardim Gramacho"
>
> (Blog do Lixo, 2017).

Regarding the environment protection around the Gas Verde plant, it seems the job has not been done properly as in February 2016 the state environmental institute (INEA) gave the company a fine of R$ 6.6 million for neglecting the leaching of poisonous substances into Guanabara bay and Sarapuí river. With the heavy rains, a waste slurry pond containing toxic contents overflowed and mixed with the slurry treated by the company. There is a canal to conduct only the treated slurry but, with the overflow, the mixed slurry was also directed to a dead arm of the Sarapuí river, reaching the Guanabara bay, explained Elaine Noce, general coordinator of INEA's inspection. According to witnesses there were at least six leaks on the pond which reached Sarapuí river's mangrove The complaint came from Jardim Gramacho fishermen who verified the reduction of the population of crabs (G1 on February, 25 2016).

Conclusion

In order to comply with international agreements for the mitigation of greenhouse gas emissions, all the nations of the globe have been seeking to solve

[4]International organization present in Latin America and the Caribbean, which has been working in Brazil for 10 years to defend the rights of people living in the most precarious and vulnerable favelas in urban centers.

the problem of environmental degradation. One of the largest pollutants by human action is the large amount of solid waste produced specially in large urban areas.

Due to Brazil's great geographic dimension and its increasing population, the recycling of urban waste is considered a difficult problem to solve. The metropolitan region of Rio de Janeiro, which for more than 3 decades maintained the largest open dump in Latin America, found in a waste to energy project an alternative to alleviate the environmental problem of the Jardim Gramacho region by producing clean energy and at the same time to avoid greenhouse gases emissions into the atmosphere. However, in the planning phase the project seemed to be the perfect solution to solve the environmental problems, but eventually created a serious social problem, since the waste pickers who worked on the dumpsite searching for recyclable materials ended up losing their livelihood.

The need to create and implement projects for the production of clean and renewable energy is undeniable, however, these initiatives shouldn't sacrifice the impoverished population that is already deprived of basic rights and citizenship. In the absence of any other alternative, poor workers have to submitted themselves to the hard work of waste picking and to live among all kinds of trash from the wealthiest layers of society. The closure irregular dumpsites is essential, but it is a urgent matter to find work and income alternatives for the hundreds of thousands of people who live from garbage dumps all over Brazil and if their dependents are considered, this number goes up to more than a million individuals.

It would be simple to say that, before solving the problem of greenhouse gas emissions into the atmosphere and search for less polluting alternative energy, government authorities should find a solution to the problem of lower social classes, providing them dignified housing conditions, schooling and proper jobs. However, the urgent need to seek alternatives to change human activities on the planet implies that public policies have to comply with socio-environmental issues and their implementation have to generate benefits for all involved actors, from the most fortunate, such as companies and the state to the most fragile, like the common citizens and the environment.

References

A Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais (2016). *Panorama de resíduos sólidos no Brasil*. Abrelpe, São Paulo.

Becker Lins, A. E. (2016). *Brasil, resíduos e as cidades: desigualdades sociais e gestão desintegrada*. ArchDaily.

Blog do Lixo (2017). *A dura realidade dos que perderam seu sustento com o fim do lixão*.

Elzen, B., Geels, F. W., y Green, K. (2004). *System innovation and the transition to sustainability: theory, evidence and policy*. Edward Elgar Publishing.

EurObserv, E. R. (2015). Biogas Barometer; 2010.

FirmGreen (2013). *Novo Gramacho opens: from trash city to green energy*.

Grin, J., Rotmans, J., y Schot, J. (2010). *Transitions to sustainable development: new directions in the study of long term transformative change*. Routledge.

Hijazi, O., Munro, S., Zerhusen, B., y Effenberger, M. (2016). Review of life cycle assessment for biogas production in Europe. *Renewable and Sustainable Energy Reviews*, 54:1291–1300.

Mattos, Z. (2016). *Lixão de Gramacho e os impactos do seu encerramento na vida dos catadores que permanecem no Polo de Reciclagem*. Departamento de serviço social. PUC, Rio de Janeiro.

Ministério do Meio Ambiente (2010). *Biogás do aterro de Gramacho beneficia associação de catadores no Rio de Janeiro*.

Pierson, R. (2013). *Landfill Methane*. Environmental and Energy Study Institute, Washington D.C.

Ribeiro, R. (2014). De Gramacho à Seropédica. *Radis-comunicação e saúde.*, 139:20.

Smith, A., Stirling, A., y Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research policy*, 34(10):1491–1510.

Sousa, F. J. (2017). *Lixão do jardim gramacho: já vai tarde? Água, vida e Cia*.

Stern, J. (2017). The Future of Gas in Decarbonising European Energy Markets: the need for.

TETO (2014). *Não fechou só o lixão. Situação do Jardim Gramacho*.

Xerez, A. A. (2013). *Mãe Rampa: Os impactos do encerramento do aterro metropolitano de Jardim Gramacho nos catadores de material recicláveis*. Universidade Federal Fluminense, Rio de Janeiro.