International Journal of Geosciences, 2020, 11, 288-303
https://www.scirp.org/journal/ijg
ISSN Online: 2156-8367
ISSN Print: 2156-8359

Spatial Distribution of Toxic Sites in Louisiana, USA: The GIS Perspectives

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How to cite this paper: Twumasi, Y.A., Merem, E.C., Namwamba, J.B., Welch, S.A., Ayala-Silva, T., Okwemba, R., Abdollahi, K., Lukongo, O.E.B., LaCour-Conant, K., Tate, J. and Akinrinwoye, C.O. (2020) Spatial Distribution of Toxic Sites in Louisiana, USA: The GIS Perspectives. *International Journal of Geosciences*, **11**, 288-303.
https://doi.org/10.4236/ijg.2020.114015

Received: February 27, 2020
Accepted: April 24, 2020
Published: April 27, 2020

Abstract

This study uses geographic Information System (GIS) techniques to spatially geocode the affected toxic site areas in Louisiana and use the results to help policy-makers plan for removal. Data for this study was acquired from the United States Environmental Protection Agency (EPA) website including names and locations of National Priorities List (NPL). Also, publicly available EPA database that contains information on toxic chemical releases and other waste management activities reported annually by regulated industry groups and federal facilities was acquired. Data obtained from EPA website was converted to geographic co-ordinates (latitude and longitude). Results showed geocoded toxic wastes maps in Louisiana. Results also revealed that most of the toxic sites were clustered around major waterways in both southern and northern Louisiana. Policy recommendations include strict enforcement of the State laws that deal with fracking and flaring, use of emission inventories and air quality reports to assist policy makers in developing cost-effective emission control strategies that are necessary for tracking the progress of policies towards gas emissions reduction and finally, the need to increase funding for the clean-up of the chemical waste.

Keywords

GIS, Toxic Waste, Superfund, Louisiana

1. Introduction

Hazardous waste sites pollution is a global problem. It is estimated that more than 500,000 humans have died and 10 million have suffered from chemical spills. In the last 40 years, about 200 million people have been at risk of exposure to toxic and hazardous waste sites pollution poisoning globally [1]. It is also observed that chemical spills contamination has taken the dimension of epidemiological problems in the United States [2] [3]. Chemical spills and hazardous waste sites are some of the major issues confronting both states and federal governments because of accompanying health-related issues [4]. Hazardous waste contamination poses a significant threat to the environment. In 1980, legislation was passed by congress to create the Superfund program at United States Environmental Protection Agency (EPA) to identify and clean up harsh hazardous waste sites to jump start and fund cleanup efforts [4]. Since then billions of dollars have been spent cleaning up Superfund sites. Toxic waste disasters are almost always associated with the industrial use of, or management of, harmful chemicals and or their by-products. Unlined or poorly lined landfill pits, leaky storage tanks and the irresponsible disposal of industrial waste are common causes which ensue hazardous waste disasters. These harmful contaminants seep into the soil from industrial sites and subsequently pollute the soil and any existing downstream water supply. The toxins render the soil unsuitable for agricultural use and the water non-potable and unsafe for domestic use, moreover, some of these toxins are known carcinogens. The EPA, through The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), also known as Superfund, endeavors to combat these environmental threats by identifying hazardous waste sites across the US where clean-up efforts will be employed. Polluted sites are added to the EPA's National Priorities List (NPL) for cleanup and remediation of the nation's uncontrolled and environmentally contaminated sites and ranked as either a long-term or short-term project (**Figure 1**). Upon completion of remedial actions, the sites are removed from the NPL list and prepared for reuse when possible. Most of these Superfund sites are clearly marked or identified with EPA sign board to show the existence of hazardous waste (**Figure 2**).

Besides health issues, dumping of hazardous waste poses a significant threat to the environment. The Environmental Protection Agency's (EPA) 1995 data shows that EPA managed about 277 million metric tons of hazardous waste at licensed Resource Conservation and Recovery Act (RCRA) sites. EPA also estimated that U.S. factories released 1.8 million metric tons (about 2 million tons) of toxic chemicals into the air, land, and surface waters in 2011, including a number of chemicals that are known carcinogens.

Each year millions of dollars are spent by both states and federal governments to clean up contaminated sites. Notwithstanding the gravity of the issue, very little has been done to track the problems with Geographic Information Systems (GIS) in Louisiana. However, GIS has found widespread appeal in mapping and

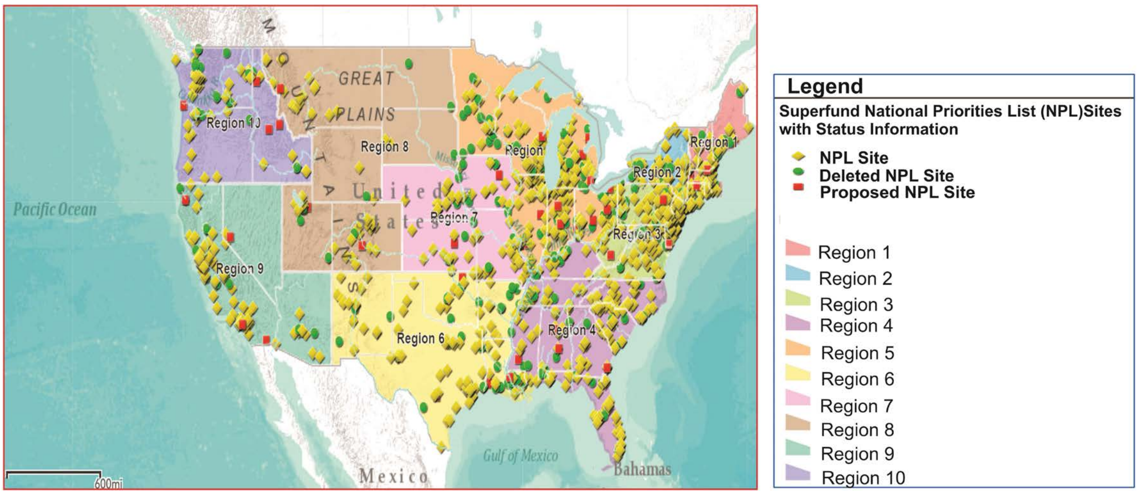

Figure 1. Superfund National Priorities List (NPL) sites with Status Information. [Image Courtesy of ESRI, NOAA, USGS and U.S. Environmental Protection Agency [4].

Figure 2. EPA Sign Board showing superfund site (Image courtesy of EPA).

analyzing chemical spills and Hazardous waste sites pollution. The study therefore uses GIS to spatially geocode the affected toxic site areas in Louisiana.

2. Geocoding of Environmental Pollution Using Geographic Information System (GIS)

GIS has emerged as an important tool for integrating geo-referenced data on pollution assessment. It is also a spatial system for the organization, storage, transformation, retrieval, and analysis of data where location is important [5]-[9]. The ability of GIS to visualize different land features and environmental dataset GIS techniques combined with other methods such as Geostatistics play an important role in geocoding of environmental pollution as well as visualization of data in a spatial environment [10] [11] [12] [13]. Numerous studies have used these tools to determine and map spatial distribution and behavior of pollutants in urban areas [14]-[24]. There are also many studies worldwide that have used GIS to locate and geocode toxic and other environmental waste pollutions [25]-[29]. Other studies such as Yesilonis *et al.* [30] combined GIS techniques with principal components analysis and univariate statistical procedures to spatially locate above-background contents of the contaminated heavy metals Cd, Co, Cu, Cr, Fe, Mn, Ni, Pb, Ti, V, and Zn in surface soils in Baltimore City. Similar work is done in urban setting, Nazarpour *et al.* [31] used GIS to spatially locate toxic metal contamination of the urban industrial city of Ahvaz in Southwest Iran. In Ho Chi Minh City, Vietnam, Quang *et al.* [32] determined the concentration and distribution of heavy metals in soil by using Geostatistics and GIS techniques. Results of their study highlighted spatial distribution and contamination of heavy metals in the city. The objectives of this study were two-fold-firstly, to use GIS techniques to spatially geocode the affected toxic site areas in Louisiana, and secondly, to use information obtained from geocoded maps to help policy-makers plan for removal of toxic material.

3. Methodology

3.1. The Study Area

The focus of this study was on the State of Louisiana (**Figure 3**). The state of

Figure 3. The state of Louisiana with the parishes.

Louisiana is no stranger to the ramifications of man-made environmental disasters after the 2010 BP Deepwater Horizon oil spill painted 55 miles of the state's coastline black, with gallons of oil [33]. Almost a decade later the state continues to battle with issues of environmental contamination due to industrial toxins. This is no surprise considering Louisiana's thriving chemical industry which directly employs over 29,000 workers across its 64 parishes. This sector accounted for $80 billion in sales in 2018 [34]. Although the chemical industry has been praised as the cornerstone of Louisiana's economy, it also greatly contributes to the downfall of environmental quality in the Bayou state. The number of sites in Louisiana on the EPA's National Priorities List (NPL) is 10, while 6 sites have been proposed to be added to the list. 13 sites, which had been previously remediated under the CERCLA act, were removed from the list [4] [35].

The list of contaminants identified across these sites was extensive, ranging from heavy metals such as lead, mercury, arsenic, and cadmium to explosives such as 2,4,6-trinitrotoluene (TNT) and dinitrotoluene (DNT), from a former Louisiana ammunitions plant. Several deposits of creosote, from old wood treatment facilities, were found in Slidell, Madisonville and Marion. Other contaminants identified included leachate from landfills, PCBs, and various organic and inorganic materials [36] [37]. There is no way of telling exactly when some of these pollutants were first introduced into the environment, but it is safe to assume that some of occurrences could be many decades old, considering the fact that some facilities had operations dating as far back as the early 1900s. The state of Louisiana, with its flourishing chemical industry, is littered with many polluted sites (**Figure 4**; **Figure 5**; **Figure 6**). There is also evidence of numerous instances of fracked gas blowout and flaring by petrochemical companies (**Figure 5**) [38]. **Table 1** provides

Figure 4. The Nutrien Gelsmar Nitrogen and Phosphate facility is seen in the foreground with several plants in the background. The bulk of Ascension Parish's heavy industry is around Gelsmar just downriver from St. Gabriel. Source: Image Courtesy of the Advocate Newspaper [36].

Figure 5. GEP Haynesville, LLC's blown out fracked gas wells in northwestern Louisiana. Source: Image Courtesy of the Advocate Newspaper [38].

Figure 6. A chemical retaining pond is seen behind the new Pelican's Crossing neighborhood near the LAlumina LLC facility (previously Almatis Alumina) in Ascension Parish. Source: Image Courtesy of the Advocate Newspaper [39].

a summary of the active and proposed Superfund sites in Louisiana, the pollutant type at each location and a brief summary of the site's industrial history.

3.2. Data Acquisition and Processing

Data for this study was acquired from United States Environmental Protection Agency (EPA) website including names and locations of NPL and Super Fund sites in the state of Louisiana. Additional data was obtained from Ormsby *et al.* [40] and data from newspapers and journal publications [41] [42]. Also, publicly available EPA database that contains information on toxic chemical releases and other waste management activities reported annually by regulated industry groups and federal facilities was acquired [43]. Data obtained from EPA website was converted to geographic co-ordinates (latitude and longitude). To add the

Table 1. Louisiana Superfund Sites, Active and Proposed. Toxic Sites on the NPL [4].

NAME	LOCATION	CONTAMINANT	PREVIOUS INDUSTRIAL USAGE
ACTIVE SUPERFUND SITES			
Agricultural Street Landfill	New Orleans	Zinc, Mercury, Cadmium, Arsenic	Landfill (est. 1910)
Bayou Bonfuca	Slidell	Creosote	Wood Treatment Facility (est. 1900)
Madisonville Creosote Works	Madisonville	Creosote	Wood Treatment Facility (est. before 1950)
Delta Shipyard	Houma	Arsenic, antimony, lead, mercury, pyrene and many other harzadous products	Cleaning and repair facility for boats and barges
American Creosote	Winfield	polychlorinated dibenzodioxins, polychlorinated dibenzofurans, and various carcinogenic and mutagenic polynuclear aromatic hydrocarbons	Wood Treament Facility (est. 1910)
Combustion Inc.	Denham Springs	PCB's volatile organic chemicals, and heavy metals (*i.e.* lead and thallium)	Handled non-reclaimable waste oil
Louisiana Army Ammunition Plant	Doyline	TNT, dinitrotoluene (DNT), phenols, 4-DNT, tetryl, and cadmium	Associated with loading, assembling, and packing military ammunitions
EVR-Wood Treating/Evangeline Refining Jennings Company	Jennings	Metals	Wood treatment facility and oil refinery
Marion Pressure Treating	Marion	Creosote	Wood treatment facility (1964-1989)
Petro-Processors of Louisiana Inc.	Scotlandville	Leachate	3 - 5 million cubic feet pf contaminated material potentially stored in on-site enclosed pits
PROPOSED SUPERFUND SITES			
Calcasieu Estuary (formerly Bayou D'Inde)	Calcasieu	Various organic and inorganic materials	Organic and inorganic materials were disposed into the Calcasieu Estuary
Colonial Creosote	Washington	Polycyclic aromatic hydrocarbons (PAHs)	Wood treatment facility
Devil's Swamp Lake	Scotlandville	PCBs	Waste management facility, hazardous waste disposal facility and discharge point for treated wastewater
Gulf States Utilities-North Ryan Street	Lake Charles	PAHs, copper and lead	Landfill for utility operations
Highway 71/72 Refinery	Bossier City	Lead and mercury	CITGO refinery site
SBA Shipyard	Jefferson Davis	TBD	TBD

data obtained from EPA website into ArcMap, information was inputted into a Microsoft Excel spreadsheet and reformatted appropriately to be able to import it into ArcGIS. Then, shape files containing the states and the parish boundaries were added to the GIS project. Using a common attribute between the GIS shape file and the Microsoft Excel file, the Microsoft Excel data was joined with the attribute table of the shape files. Summary of data acquisition and processing and are shown in Figure 7.

4. Results and Discussion

Figure 8 shows geocoded EPA toxic sites in Louisiana. Figure 9 also displays some of the abandoned pits in Louisiana. Figure 10 and Figure 11 display an abandoned pit and remediation Plan Sites, and 2019 Louisiana toxic release inventory, respectively. The abandoned pits shown in Figure 9 pose risks to underground and surface water systems that might be polluted from rainwater and surface runoff, respectively. They also pose health risks to the community living close

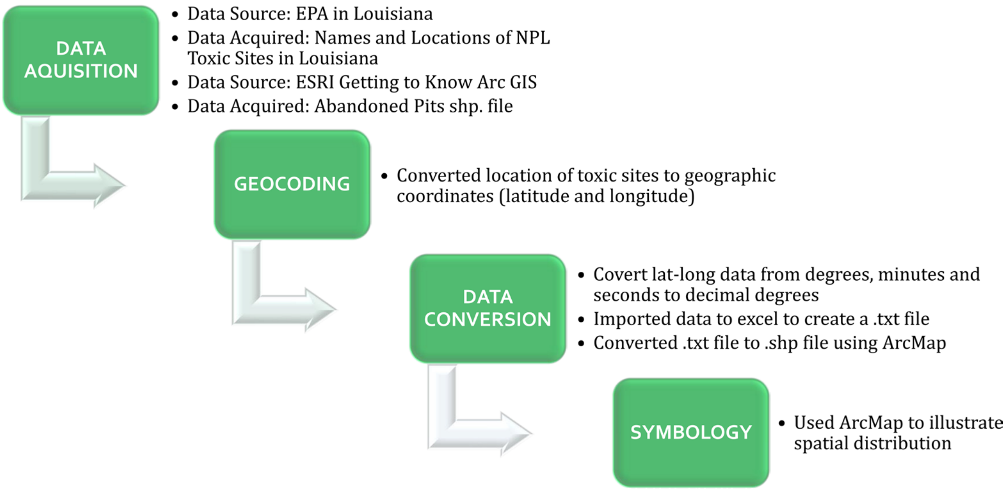

Figure 7. Data acquisition and processing flow chart.

Figure 8. Geocoded EPA toxic sites in Louisiana.

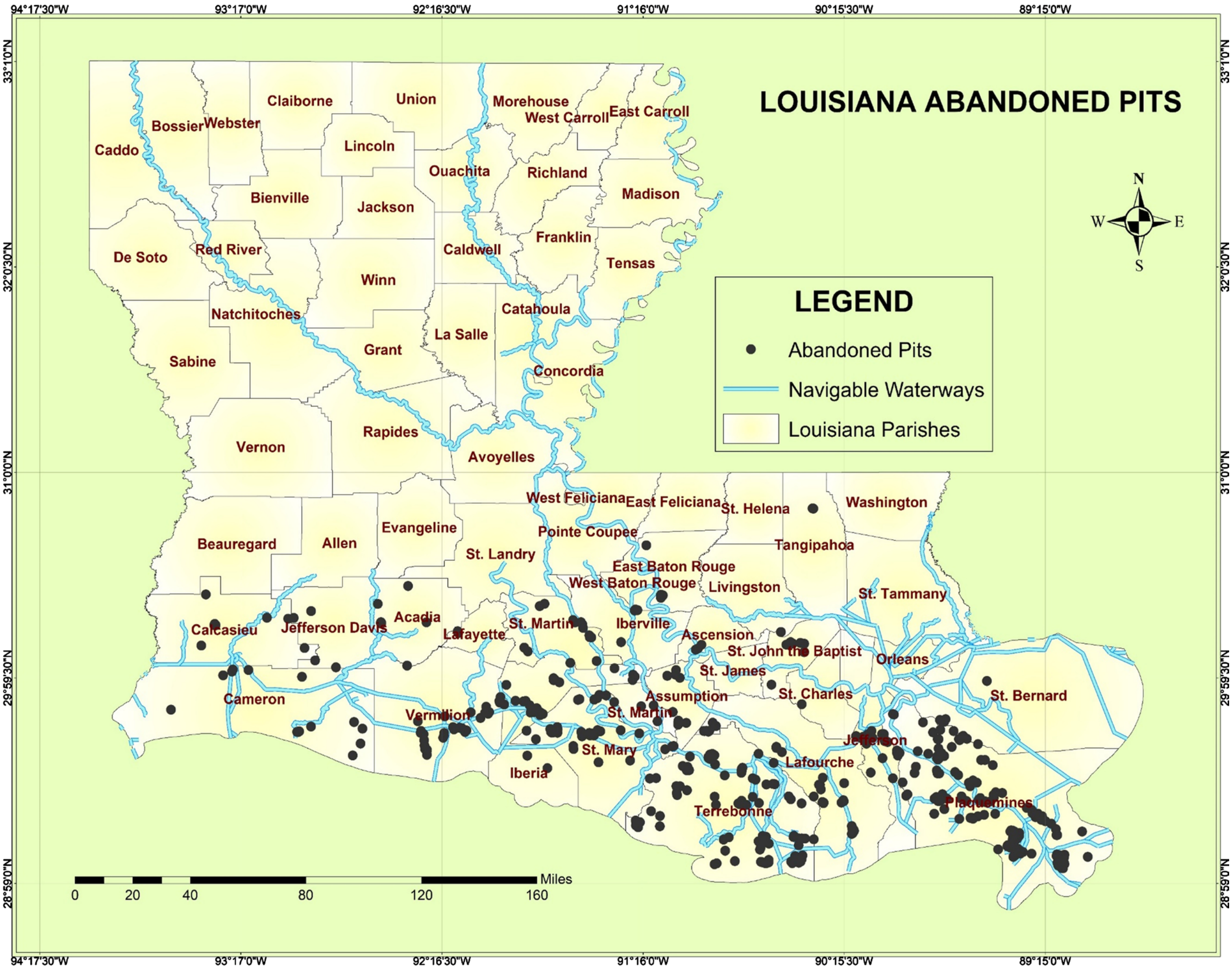

Figure 9. Abandoned pits in Louisiana.

to the facility through breathing air associated with toxic pollutants. Inhaling or breathing toxic air pollutants could increase chances of experiencing health problems [2] [3]. Across the state of Louisiana, 60% of NPL listed toxic sites are either in direct contact with or in close proximity to major waterways, and 75% are distributed across the southern Louisiana region (Figure 9 and Figure 10). Studies have shown that race, ethnicity, and other socioeconomic factors such as property value and educational attainment, strongly affect the location of hazardous waste sites [44] [45].

Dozens of contaminated toxic sites are scattered across Louisiana. 10 sites are on the EPA's NPL 606 abandoned pits. Hazardous waste pollution has extensive ecological impacts. Leaching of toxic chemicals and byproducts can cause soil contamination, increasing community exposure risks and making land unfit for agricultural use. Contamination of ground and surface water supplies threatens availability of clean water for consumption and agricultural use. Additionally, contaminants can cause health declines in exposed flora and fauna, threatening ecosystem structure and function. Further impacts of toxic waste on ecosystems

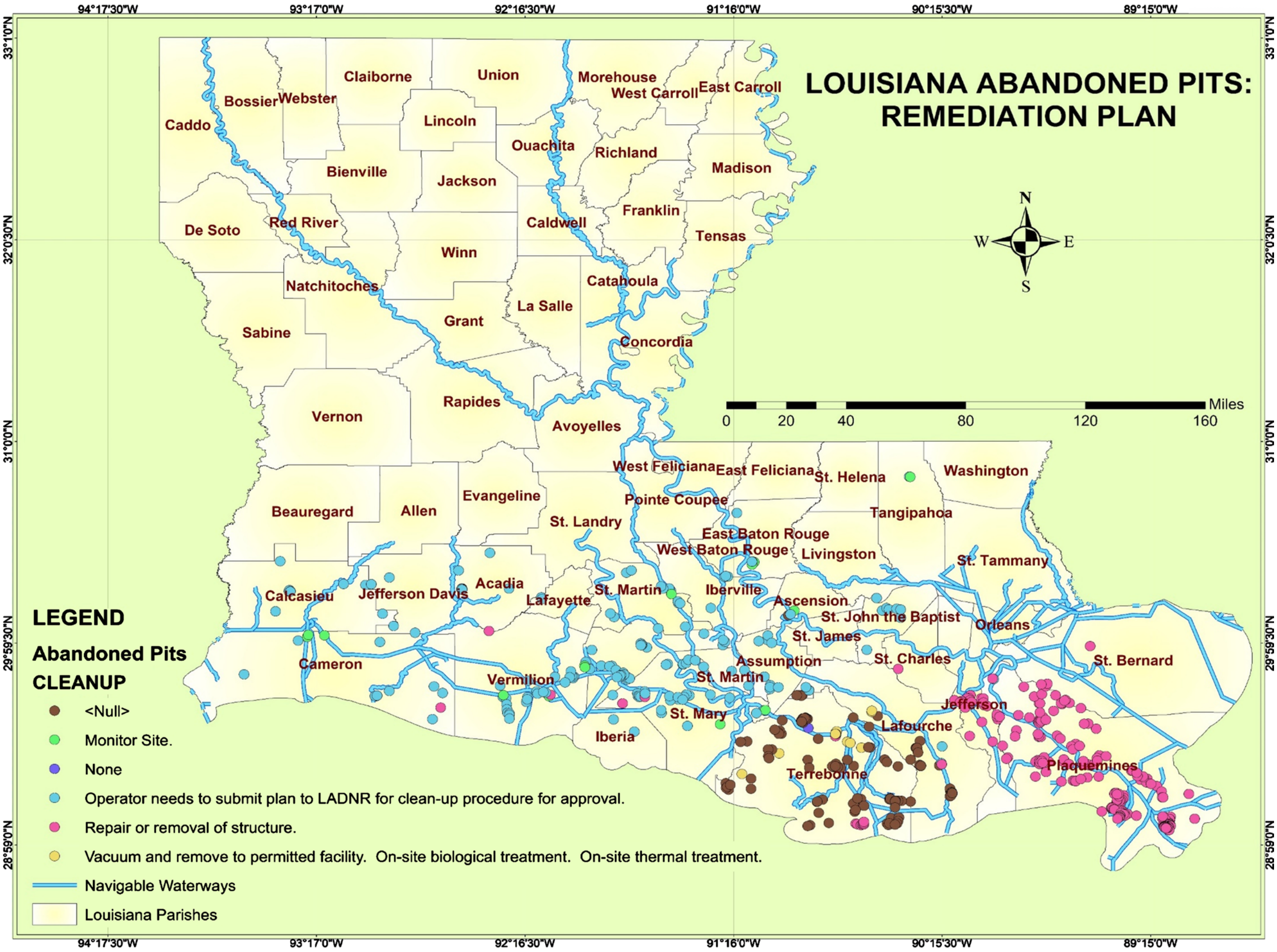

Figure 10. Abandoned pits and remediation plan sites in Louisiana.

is shown in **Figure 13** [46]. Contaminants include heavy metals, carcinogens and lead. Hazardous waste contaminates the environment and water supplies. It also kills marine wildlife and creates uninhabitable environments. The abandoned pits remediation plan shown in **Figure 12**, gives details steps to be taken in order to clean the chemical wastes from the environment.

This study found that some activities, by petrochemical companies contributing significantly to pollution via fracked gas blowout and flaring (burning of chemicals in an open flame) were commonly practiced as shown in **Figure 5** [37]. Gas flaring is one of the causes of emission. It also generates toxic compounds that harm human health and the ecosystem. Several studies have shown that not only is plant productivity affected, but also soil characteristics as well as contamination of surface drainage systems [26] [47].

5. Policy Recommendations and Conclusion

To tackle the issue of flaring with attendant emission problems, there is the need for strict enforcement of the State law that deals with fracking and flaring. Companies found guilty should be made to pay heavy fines and clean up or even

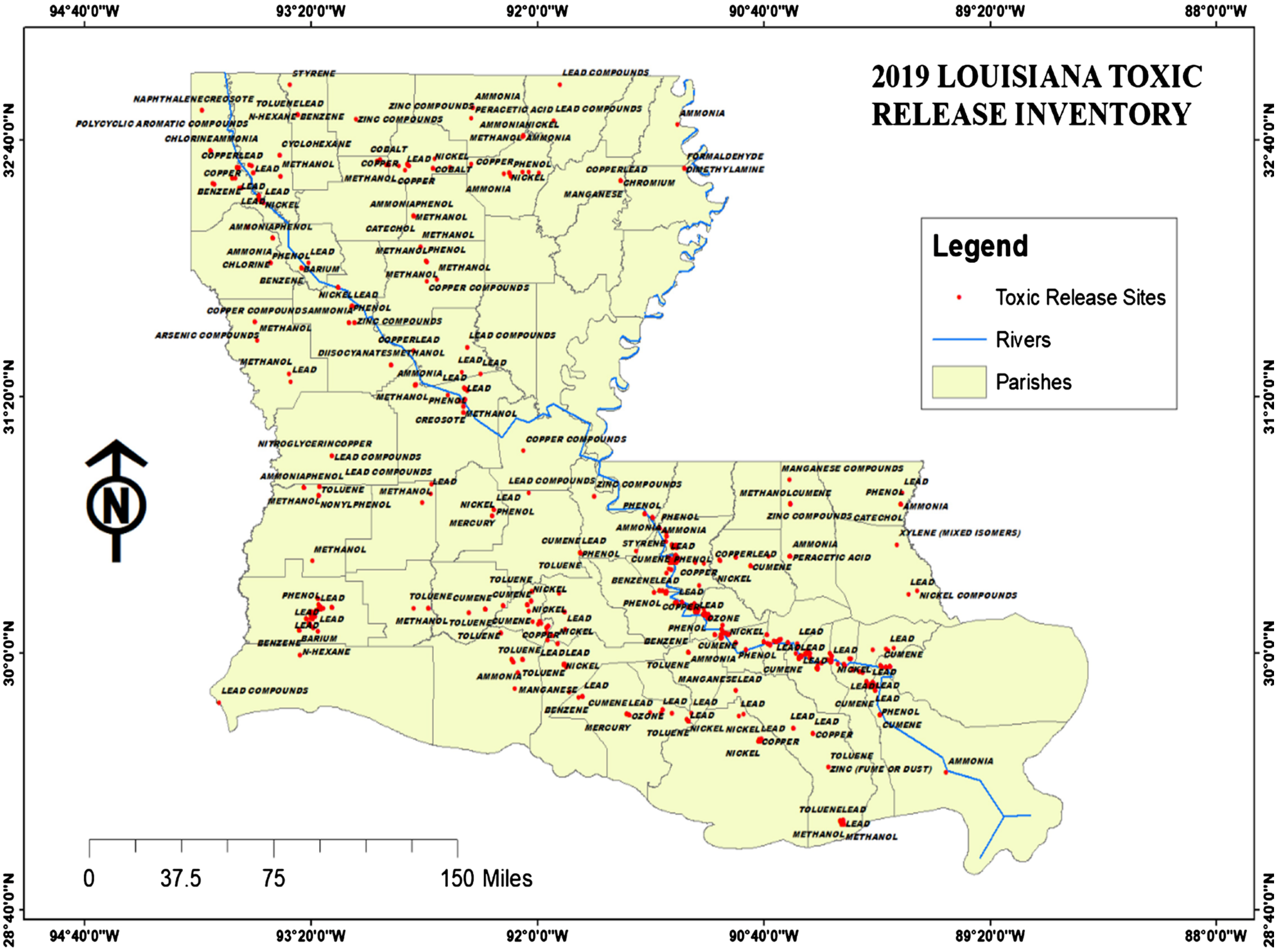

Figure 11. 2019 Louisiana toxic release inventory.

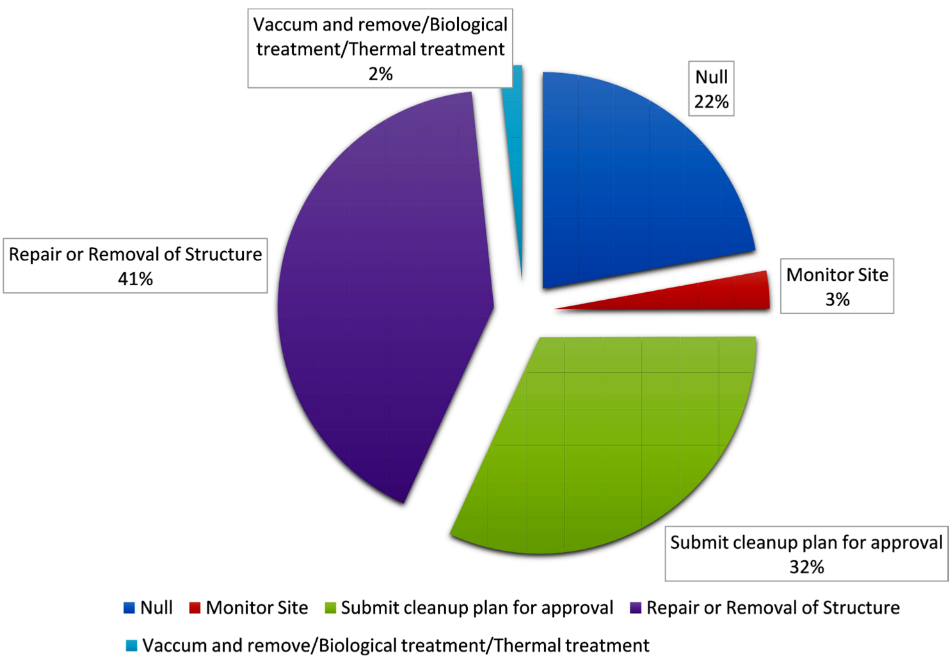

Figure 12. Abandoned pits remediation plan.

Figure 13. Some of the ecological impacts of toxic waste.

close their operations. Each year Louisiana Department of Environmental Quality and EPA publish emission inventories and air quality reports. Scientists should be made to use inventories of emissions as tools when developing atmospheric models. This would assist policy makers in developing cost-effective emission control strategies that are necessary for tracking the progress of policies towards gas emissions reduction. Recent announcement by Governor John Bel Edwards to address sea level rise by reducing greenhouse gas emissions from the oil and gas industry [48] is in the right direction, since, emissions play an important role in global warming. There is also the need to increase funding for the clean-up of the chemical waste. Report by Mitchell [49] noted with concerns about lack of funding to clean up the chemical waste. Most of the hazardous facilities could not be cleaned as fast as possible because of lack of funding. Accordingly, without remedial action, the extent of contamination would expand, and the impacts will continue to worsen.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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