IDENTIFICATION AND MAPPING OF RAW SEWAGE DISCHARGE POINTS IN MINNA, NIGERIA

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Abstract

As part of a suite of studies substrated on the purpose-specific Geographic Information System (GIS) of Minna, Niger State, Nigeria, a raw sewage pollution profile layer of this GIS was a natural choice to complement the other air pollution studies that were components of this suite; these air pollution studies were concerned with the measurements of the ambient concentrations of noise, carbon monoxide, and sulphur dioxide at the major stalling traffic points in Minna. The creation of a raw sewage discharge profile GIS layer for Minna town would contribute immensely to the public health repository database of the Niger State Government; such a database would form a critical component of the public health policy formulations of the government. About 211 distinct stations of interest in Minna were identified, individually georeferenced, and these values were archived on the Minna GIS. Subsequent processing led to the creation of the raw sewage discharge layer for the Minna GIS. This GIS layer is now a veritable audit mechanism tool in the hands of GIS managers and public health officials charged with enforcing strict hygiene codes. It is recommended that the other major towns of Niger State (i.e. Bida, Kontagora, and Suleja) be brought into this scheme as a pilot project with the long-term objective of replicating this study across the major settlements of Nigeria.

Keywords: GIS, GIS layer, Georeference, Raw sewage, Hazard

Introduction

Knowing the extent of the raw sewage discharge problem should be of interest to the overseeing authority charged with public health issues, that is, the Niger State Environmental Protection Agency (NISEPA). It is as a result of these considerations that this study was undertaken such that the raw sewage discharge profile of Minna town could be mapped as a Geographic Information System (GIS) layer.

Sewage: According to the encyclopaedia Wikipedia (www.en.wikipedia.org); Sheri Lamb (www.ehow.com); Malachi Lloyd Green (www.ehow.com), raw sewage is mainly water containing excrement, industrial release and debris such as sanitary towels, condoms and plastic. Excrement is the major source of harmful micro-organisms, including bacteria, viruses and parasites. It is also water-carried waste, in solution or suspension that is intended to be removed from a community. It is more than 99% water and is characterized by volume or rate of flow, physical condition, chemical constituents and the bacteriological organisms that it contains. Sewage treatment reduces the water content and removes debris, but does not kill or remove all the microorganisms.

Classes of Sewage:The encyclopaedia Wikipedia; Sheri Lamb (www.ehow.com); Malachi Lloyd Green (www.ehow.com) sources further indicated that classes of sewage include sanitary, commercial, industrial, agricultural and surface runoff. The wastewater from residences and institutions, carrying body wastes, washing water, food preparation wastes, laundry wastes, and other waste products of normal living, are classed as domestic or sanitary sewage. Liquid-carried wastes from stores and service establishments serving the immediate community, termed commercial wastes, are included in the sanitary or domestic sewage category if their characteristics are similar to household flows. Wastes that result from an industrial process or the production or manufacture of goods are classed as industrial wastewater. Their flows and strengths are usually more varied, intense, and concentrated than those of sanitary sewage. Surface runoff, also known as storm flow or overland flow, is that portion of precipitation that runs rapidly over the ground surface to a defined channel. Precipitation absorbs gases and particulates from the atmosphere, dissolves and leaches materials from vegetation and soil, suspends matter from the land, washes spills and debris from urban streets and highways, and carries all these pollutants as wastes in its flow to a collection point.

What is a Sewage Spill? Sewage spills occur when the wastewater being transported via underground pipes overflows through a manhole, cleanout or broken pipe. Sewage spills cause health hazards, damage homes and businesses, and threaten the environment, local waterways and beaches. Septic system failure can also result in exposure to sewage. Improper homeowner maintenance is the most common reason for septic system failure. If poorly maintained systems are not pumped out regularly, they have sludge (solid material) build-up inside the septic tank. Sewage then flows into the absorption field, clogging it beyond repair. Heavy rains can saturate septic fields, causing systems to overflow and fail [www.en.wikipedia.org; Sheri Lamb (www.ehow.com); Malachi Lloyd Green (www.ehow.com)].

How can People be Exposed to Sewage? People are exposed to sewage by hand-to-mouth contact during eating, drinking and smoking, or by wiping the face with contaminated hands or gloves. Exposure can also occur by skin contact, through cuts, scratches, or penetrating wounds, and from discarded hypodermic needles. Certain organisms can enter the body through the surfaces of the eyes, nose and mouth and by breathing them in as dust, aerosol or mist [www.en.wikipedia.org; Sheri Lamb (www.ehow.com); Malachi Lloyd Green (www.ehow.com)].

Hazards of Untreated Sewage: Every year hundreds of billions of gallons of untreated sewage flow into our rivers, lakes, and coastal waters. Unknowingly, many Americans and their loved ones risk serious illness when untreated sewage seeps into the water they use for recreation or drinking. The United States Environmental Protection Agency (USEPA) estimates that over 7 million people suffer from mild to moderate illnesses caused by untreated sewage every year. Another ½ million get seriously ill. However, the number of illnesses caused by raw sewage could be much higher than we think. Many people that get sick from untreated sewage are not aware of the cause of their illness and do not report it to their doctors or local health officials [www.en.wikipedia.org; Sheri Lamb (www.ehow.com); Malachi Lloyd Green (www.ehow.com)].

On Georeferencing: Because of the need to ensure independent verification of the results being presented, it is instructive to adopt the practice of georeferencing survey stations. Jonah and Duromola (2014A), Jonah and Ayofe (2014B), Jonah and Bawa (2014C), Jonah and Olasehinde (2014I), Jonah *et al.* (2014D; 2014E; 2014F; 2014G; 2014H), Jonah and Jimoh (2013A), Jonah *et al.* (2013B; 2013C; 2013D), and Jonah *et al.* (2011A; 2011B; 2011C; 2011D) have always argued in favour of georeferencing field data and their concomitant tie-in to their specific GIS database.

Statement of the Problem

It is recognized that, at present, there exist no specific studies targeted at mapping the raw sewage discharge profile of Minna, especially one that is substrated on a Geographic Information System platform.

Justification of the Problem

The creation of a raw sewage discharge profile Geographic Information System layer for Minna would contribute immensely to the public health repository database of the Niger State Government. Such a database would form a critical component of the public health policy formulations of the Niger State Government.

Aim and Objectives of Study

The aim of this study was to map raw sewage discharge profile in Minna town using Geographic Information System.

This study's overall objectives are to achieve the critical aim defined above. These objectives are, to wit:

(i). The creation of a purpose-specific Geographic Information System (GIS) for Minna

(ii). The formulation of a framework for public hygiene education for the Niger State Government.

Literature Review

Chakona (2003) carried out a research on the ecological and health implications of raw sewage spills in St Mary's, Chitungwiza. He analyzed the biological and chemical composition of the sewage water. The levels of bacterial pathogens, namely Escherichia coli, Shigella spp, Salmonella spp, faecal Streptococci and coliform (bacterial pathogen indicators) which indicate that there are health and ecological risks within the study area were taken. The most immediate health risks were potential widespread outbreak of waterborne diseases such as cholera, dysentery, diarrhoea, gastroenteritis, hepatitis and respiratory illnesses. In addition to waterborne diseases, there were also health problems caused by toxic sewage gases such as hydrogen sulphide, carbon dioxide, methane and ammonia. Ecological hazards ranging from groundwater and surface water contamination, algal blooms in Manyame River and Lake Chivero, fish kills, proliferation of macrophytes and supporting of toxic algal species were discovered. Continuous nutrient loading into Lake Chivero, that were already hyper-eutrophic, was seen to unset the ecological balance of the river and the lake.

The raw sewage also exacerbated the problems of water scarcity faced by the country. There was thus an urgent need to establish proper disposal methods for the raw sewage in this residential area in order to abet these impacts. The most immediate call was to improve/upgrade the efficiency of the operations of the sewage treatment works.

Kumar *et al.* (2012) in a de-conjugation behavior of conjugated estrogens in the raw sewage, activated sludge and river water, studied the behavior of estrone-3-sulphate (E1-3S), estradiol-3-sulphate (E2-3S), estrone-3-glucuronide (E1-3G) and estradiol-3-glucuronide (E2-3G) in raw sewage, activated sludge and river water using microcosms, their results were compared with observations at three sewage treatment plants.

The glucuronide conjugates had a half-life of 0.4 h in raw sewage, yielding 40-60% of their free estrogens. Field observations suggested complete transformation of the glucuronide conjugates in the sewer. In river water glucuronide conjugate half-lives extended to over two days yielding 60-100% of their free parent estrogens. Transformation of the sulphate conjugates in raw sewage and river water was slow with little formation of the parent estrogens. Sulphate conjugates could readily be detected in sewage influent in the field studies. In activated sludge the sulphate conjugates had half lives of 0.2 h with the transient formation of 10-55% of the free parent estrogens.

Field studies indicated transformation of sulphate conjugates across the sewage treatment, although a proportion escaped into the effluent. These results broadly support the view that glucuronide conjugates will be entirely transformed within the sewer largely to their parent estrogens. The sulphate conjugates may persist in raw sewage and river water but are transformable in activated sludge and, in the case of E2-3S, reform a high proportion of the parent estrogen.

Tantawy *et al.* (2012) characterized a raw sewage sludge using x-ray diffraction (XRD) and other techniques (the FTIR, SEM, and TGA); this raw sewage was incinerated in temperature range of 650–950°C for 2h. The effect of incineration temperature on the microstructure and pozzolanic activity of the resultant ash was investigated by techniques mentioned above as well as Chapelle test.

They concluded that incineration of sewage sludge affects the microstructure and pozzolanic activity of the resultant ash. During incineration at temperatures lower than 800°C, amorphous silica captured fixed carbon resulting from incomplete combustion conditions whereas at higher temperatures crystallization of amorphous silica was enhanced. Hydration products formed from hydrothermal treatment of silica fume with lime was amorphous whereas that of sewage sludge ash was fibrous. Hence, incineration of sewage sludge ash must be optimized at 800°C to preserve the pozzuolanic activity of the resultant ash.

Sturtevan *et al.* (1971) examined raw sewage for the incidence of antibiotic-resistant coliforms present among both total and fecal coliforms. In both groups, they found that approximately 3% of the coliform bacteria were resistant to two or more antibiotics. Of these organisms, 48% were capable of transferring all or part of their antibiotic resistance to an antibiotic-sensitive, F^-, derivative of Escherichia coli K-12. Among the R factors identified, those conferring resistance to streptomycin-tetracycline, ampicillin-streptomycin-tetracycline, and ampicillin or ampicillin-streptomycin accounted for 23, 20, and 15%, respectively, of the total R factors detected. The data indicated a significant level of infectious drug resistance among the fecal coliforms of the urban population. The data indicated further that because of the high incidence of coliform bacteria found to be doubly resistant to streptomycin and tetracyline, the inclusion of these antibiotics in selective media used for routine total or fecal coliform counts may serve to identify domestic sources of pollution.

Research Methodology

Area of Study: The Minna built-up town centre (from the Maryam Babangida Girls Science Secondary School in the north to the Abdulkareem Lafene State Secretariat in the south, and the southwest-northeast Kpakungu-Maitumbi axis), was covered for this study, see Fig. 1.

Type of Data: The information required here were solely the georeferenced specifications of the actual locations on ground of raw sewage disposal sites. Factors that exacerbate raw sewage disposal problems, such as weather, cultural norms, and population pressures were outside the scope of this study.

Method of Data Collection/Tools: The areal extent of Minna town was earmarked for this survey, initially understood to cover all of Maikunkele province to Chanchaga and all of the outlying neighbourhoods of Kpakungu to the outlying neighbourhoods of Maitumbi. However, because of the need to create a Geographic Information System (GIS) layer of raw sewage discharge signature substrated on an existing Minna GIS, and because the existing Minna GIS was substrated on the acquired analogue map of Fig.1 the areal extent selected for this project work included the northernmost vicinity of the Maryam Babangida Girls Science Secondary School to the southernmost vicinity of the Abdulkareem Lafene State Secretariat, and the southwest-northeast Kpakungu-Maitumbi axis.

Within the areal extent identified for this survey, georeferencing the locations of recognized sewage discharge problem was basically a house-to-house “on-the-spot-assessment” scheme, sort of. In order to maintain some sense of pattern and order in the georeferencing scheme, an east-west traverse was chosen with a gradual southerly progression. Any raw sewage discharge spot, whether associated with a household (the most common) or an open lot (like those at abattoirs

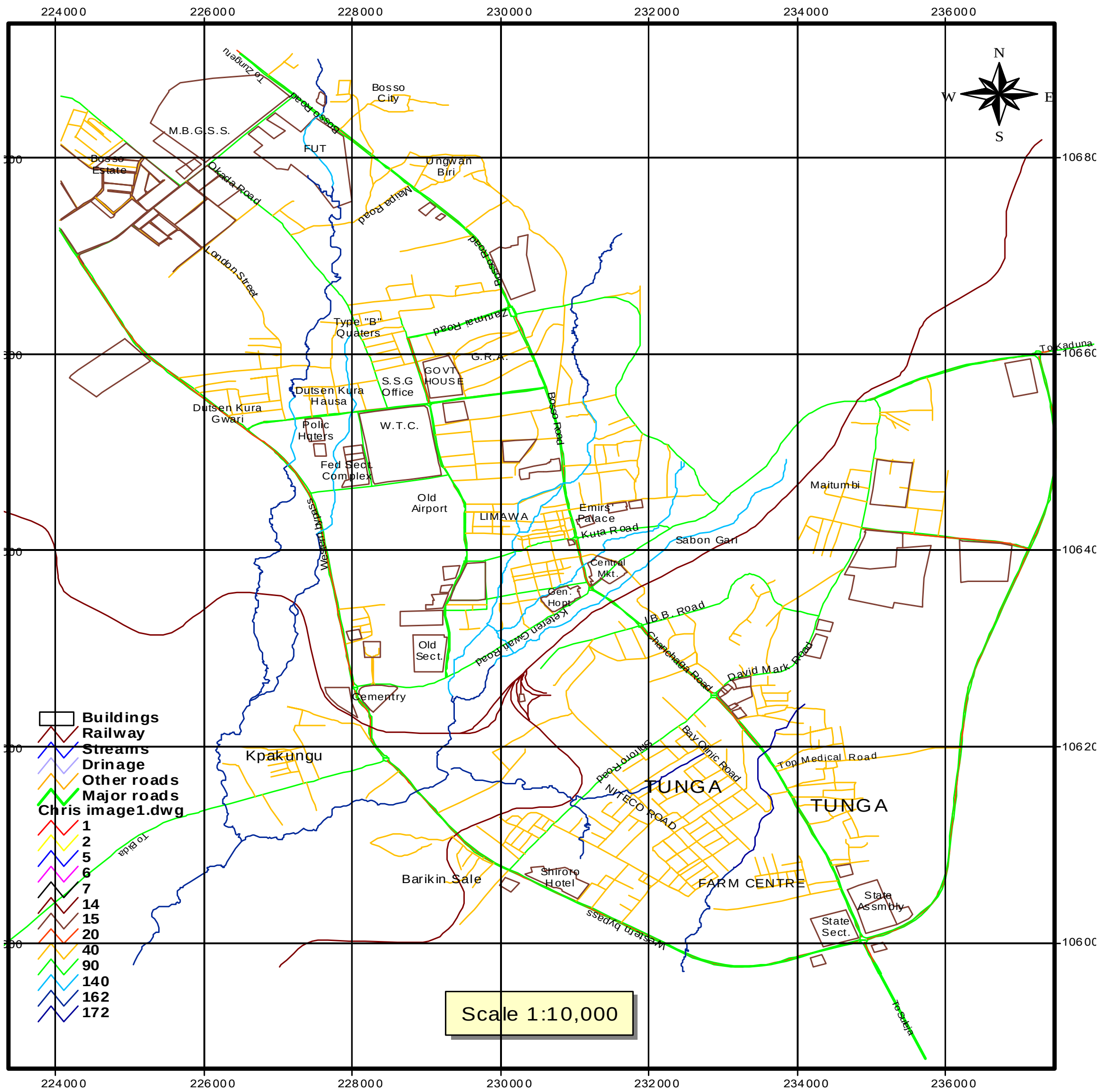

Figure 1: Map of Minna

and meat cutter's premises) was appropriately georeferenced whilst other conventional identifiers (like typical street locations and elevations above mean sea level) at that particular location were recorded.

About 211 distinct stations of interest were identified for this study; all of the neighbourhoods within the defined areal extent of this project exercise (i.e. Bosso Estate, Bosso Province, Angwan Biri, Type "B" Quarters, Dutsen Kura Gwari, Dutsen Kura Hausa, Government Reservation Area, Limawa, Old Airport Quarters, Angwan Daji, Sabon Gari, Kpakungu, Tunga, Barkin Sale, and Farm Centre) were visited in the course of this survey.

The compass was used extensively during the course of this survey as a *key direction-finder*. Since the map of Fig.1 has a directional icon indicating the four cardinal points, the compass enabled the survey party to confirm that the vicinity of Maryam Babangida Girls Science Secondary School (the most northern of the stations of interest) is truly northward of the staging or muster point for this survey, i.e. the Federal University of Technology, Minna's

Bosso Campus. The compass was also used in tandem with the hand-held Global Positioning System (GPS) unit to eliminate any doubt whatsoever as to whether the study group members were on an exact straight course, when this information was desired.

The Garmin *etrex* hand-held Global Positioning System (GPS) unit was employed chiefly for georeferencing of stations of interest during the course of this survey; it was also used in tandem with the field compass, for a minor role sort of, to confirm a defined “rectilinear” direction.

Method of Data Analysis

The raw sewage discharge-point GIS layer for this study was substrated on the existing Minna Geographic Information System (MGIS). The composite GIS raw sewage discharge-point map is shown in Fig. 2. The following sequences explain the implementation of the creation of the raw sewage pollution layer:

Step 1: Copy Raw Sewage data to notepad, see Fig.3.

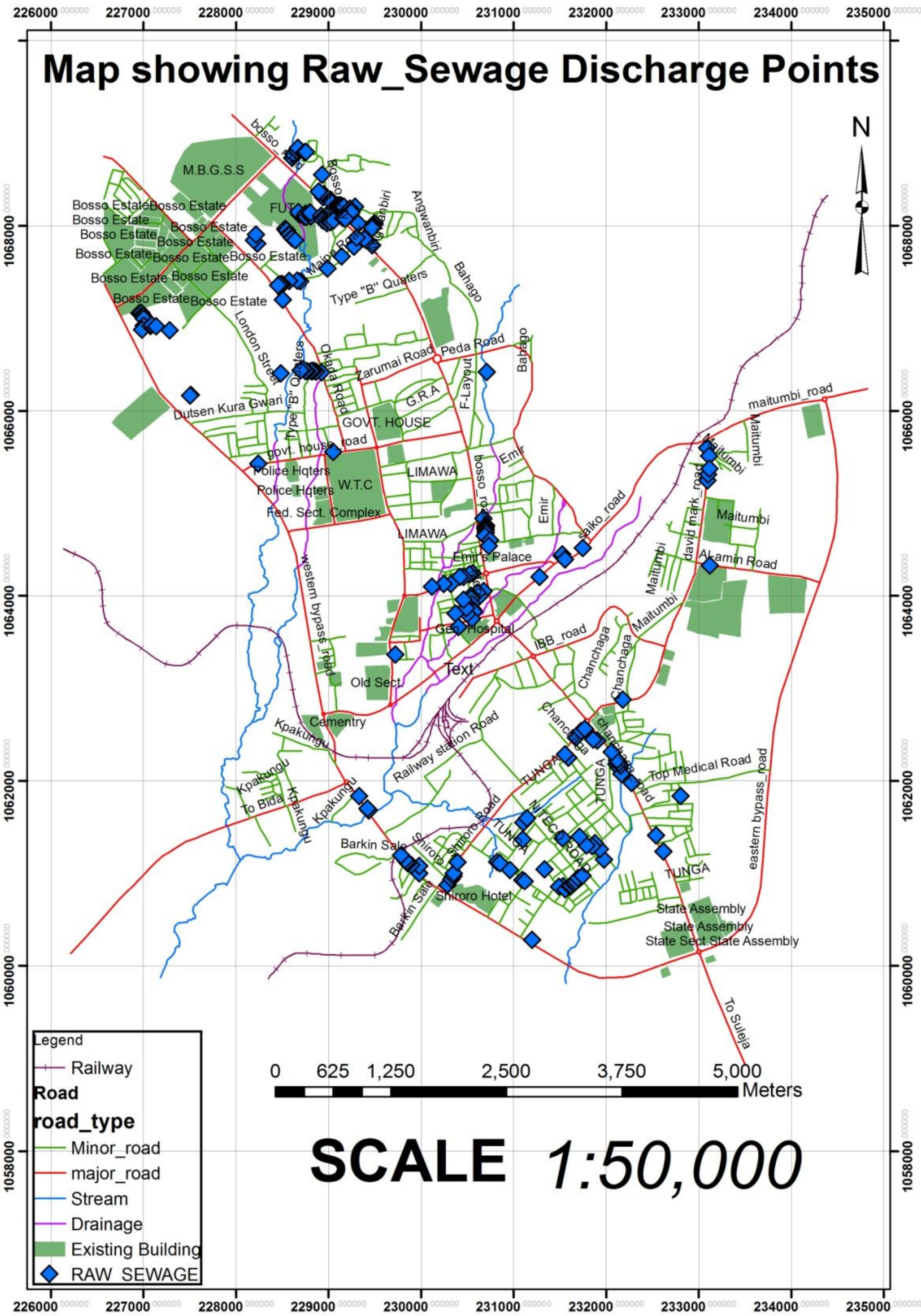

Figure 2: Composite map of the MGIS with the raw sewage layer enabled. (The blue diamond icon indicates locations where raw sewage discharge is a nuisance)

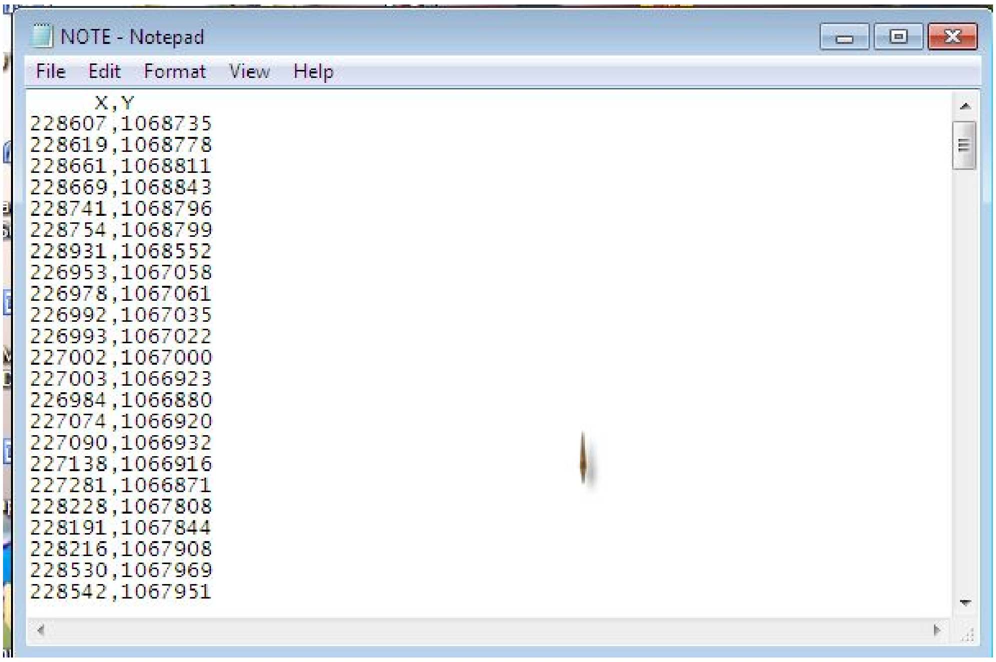

Figure 3: The Dialog box for Step 1

Step 2: Click on tools and add XY data, see Fig.4.

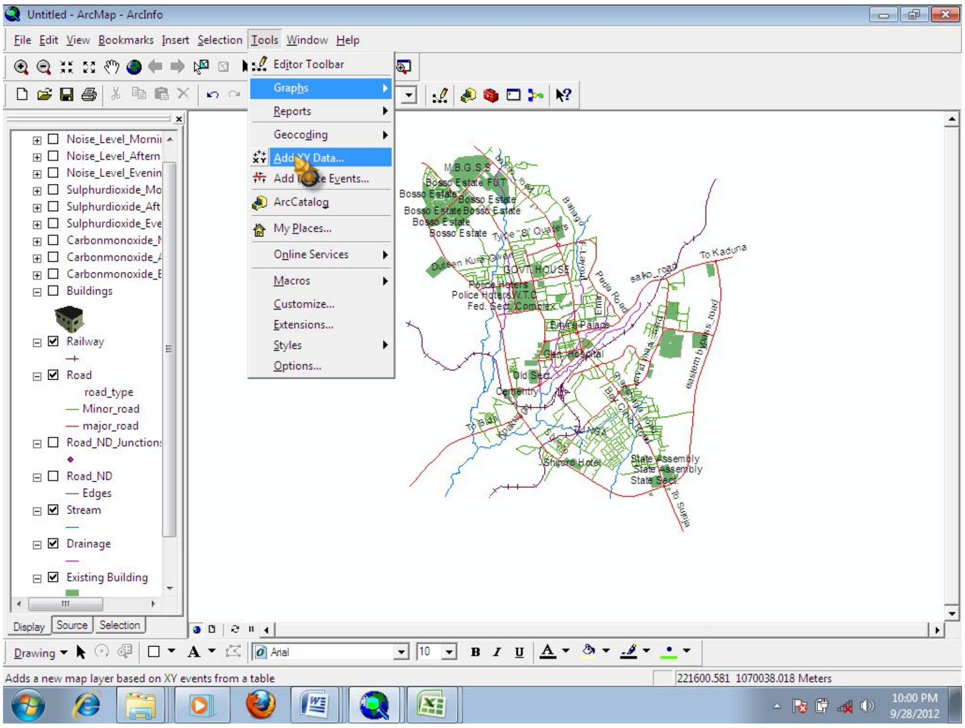

Figure 4: The Dialog box for Step 2

Step 3: Browse Raw Sewage data from directives, see Fig.5.

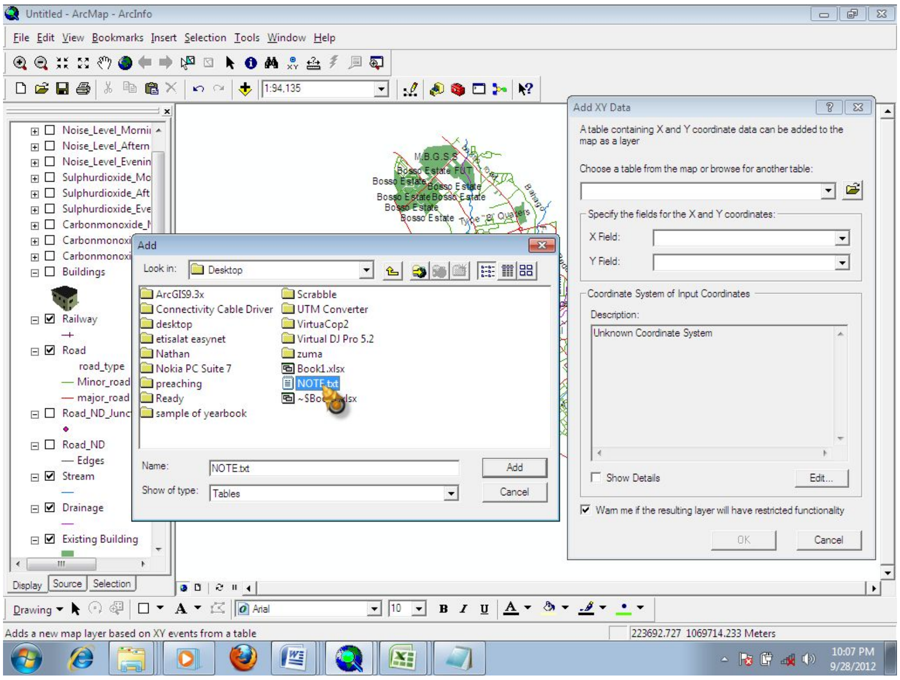

Figure 5: The Dialog box for Step 3

Step 4: Set the projection, see Fig.6.

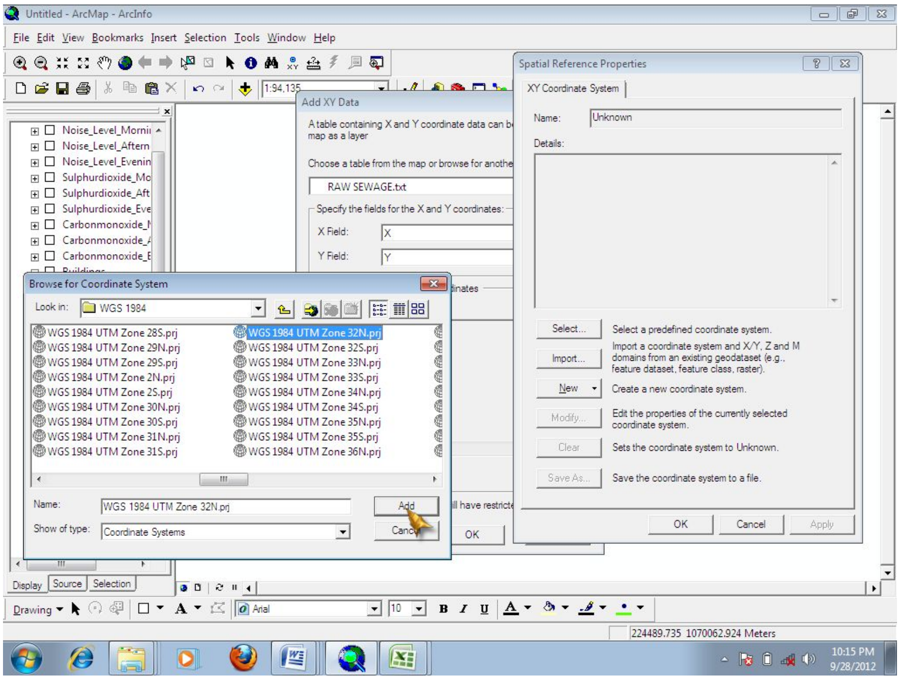

Figure 6: The Dialog box for Step 4

Step 5: Click OK, see Fig.7.

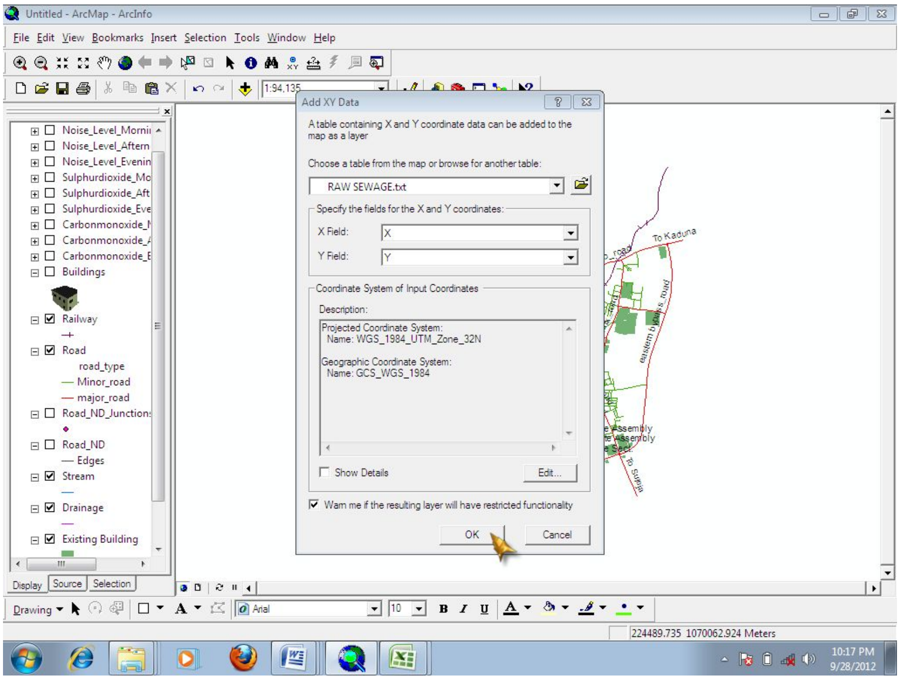

Figure 7: The Dialog box for Step 5

Step 6: Show layer on the digitized map, see Fig.8.

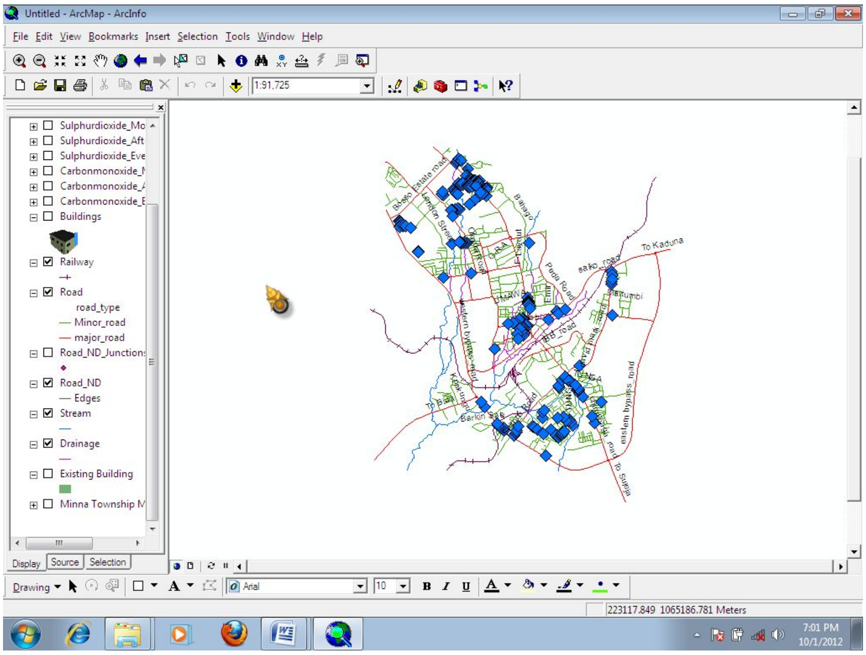

Figure 8: Shows the Dialog box for Step 6

Discussion

About 211 distinct stations of interest were initially georeferenced, and the values were archived on the Minna GIS. Like was pointed out earlier, the key identifier in this study were mainly the co-ordinates at the locations on ground where raw sewage disposal is a nuisance. Since this endeavour is a pioneering effort in this unique direction, the georeference key identifiers were sufficient for this pilot study; information regarding householders' profiles, economic status, etc., for this kind of study would be necessary in the follow-up surveys. Having thus completed the georeferencing scheme, subsequent processing led to the creation of a new layer for the Minna GIS (that is, the raw sewage discharge layer) as seen in Fig.2: in this figure, the locations where raw sewage discharges are a problem have been highlighted in blue hues.

Conclusion

For the first time, a raw sewage discharge GIS layer has been created for Minna town: this layer is now a veritable audit mechanism tool in the hands of GIS managers and public health officials charged with enforcing strict hygiene codes.

Recommendation

The areas highlighted in blue hues on the map are problematic locations because of the risk to public health that they pose to the immediate householders and the public in general. The result of this survey should help inaugurate a special "Niger State Government Intervention Scheme" whereby any householder who is at default of sewage sanitation would be a participant-beneficiary of this scheme: The householder providing labour and the Niger State Government providing materials to jointly build a proper sewage disposal system for the defaulting household. Where this pilot study is deemed successful for Minna, this idea could be extended to other major towns of Niger State (i.e. Bida, Kontagora, and Suleja) in the short-term, with the long-term objective of replicating this study across the major settlements of Nigeria.

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