GIS-BASED APPROACH FOR OBSOLETE POPS PESTICIDE DISPOSAL SITE OPTIMIZATION

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Abstract

China's large agricultural industry and heavy dependence on agro-chemicals resulted in about 574,000 tonnes of POPs pesticides production through the end of 2004. Obsolete POPs pesticide and associated wastes have been identified in 44 POPs pesticide manufacturing plants and a number of distribution and end user sites. The total quantity of pesticide POPs wastes in China is estimated to be 8,000 to 10,000 tons, and the highly pullulated soil (above 50 ppm) might exceed 1,200,000 tons based the estimation for the two DDT and two HCB and chlordane manufacturers manufacturing sites in NIP, which are widely distributed in 14 provinces. This study aims to find optimal route between the given POPs sites, either the shortest path between them or the route having minimum travel time and transposition cost. Three scenarios- one centralized POPs disposal center, one mobile facility for all the POPs sites and one centralized plant plus one mobile facility were simulated based on the NETWORK module available in ArcGIS for the Road Network analysis and the resulting routes for various origin and destination points. The transposition distance and cost were also calculated for each of the scenario according to both the short-term case for only POPs stockpiles and the long-term case for the high polluted soil. The results show that a centralized disposal center is not suitable for the treatment of large volume of high POPs-polluted soil, while re-installation cost should be considered fully for a mobile disposal facility, in the point of view to attain a lower waste transportation cost.

1. Introduction

Obsolete POPs pesticide and associated wastes have been identified in 44 POPs pesticide manufacturing plants and a number of distribution and end user sites in China[1,2], which are widely distributed in 14 provinces, including obsolete pesticides, solid residues, liquid wastes, soil and sediment of DDT, HCB, PCP-Na, toxaphene, chlordane, mirex and dicofol.. The scale of this risk and its global consequences make it a uniquely Chinese issue with significant trans-boundary impact[3]. According to the NIP, those obsolete POPs pesticide identified should be properly be handled or disposed to minimize the potential environmental risks associated. Under the support of Global Environmental Facility (GEF), China is just preparing a full-sized project titled environmentally sound management and disposal of obsolete POPs pesticides and other POPs wastes in China (POPs ESM project) to implement its obligation for the Stockholm Convention of POPs with the United Nations Industrial Development Organization (UNIDO) as the international executive agency. One or two final disposal centers will be setup to provide for treatment according to Stockholm Convention and Basel Convention guidelines of a minimum of 10,000 tons of identified targeted POPs pesticide wastes based on the project concept.

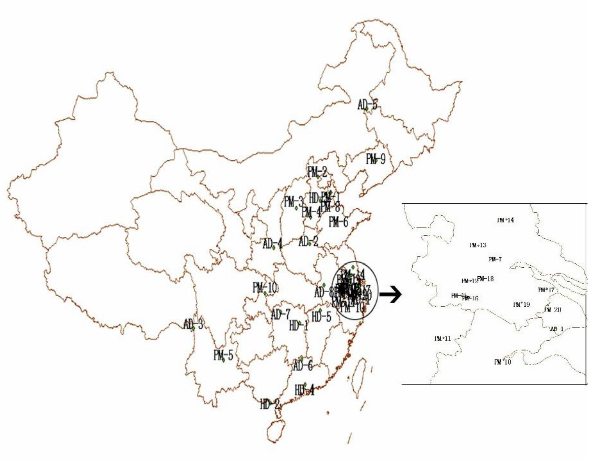
With the tremendous volume of transportation of obsolete POPs pesticides, there are more and more frequent accidents. Unlike ordinary traffic accidents, the occurrence of accidents of obsolete POPs pesticides will lead to enormous destructive and dangerous disaster[4], such as leakage, explosions, pollution of environment and so on. The site selection is one of the key factors to reduce the transportation cost and the environmental risk associated. Moreover, based on a field survey of four old pesticide POPs manufacturers that had been evaluated chemically and physically, monitoring and analysis results show that two DDT manufacturers had an estimated amount of 90,000 tons soil with a contamination level above 50 ppm, and two HCB and chlordane manufacturers have an estimated amount of 20,000 tons of soil with a contamination level above 50 ppm. Accordingly, the estimated high polluted soil might exceed 1,200,000 tons, when a scientific approach is urgently need to optimize the transportation of obsolete POPs pesticides in all material aspects to protect the public and social security in a long term view.

Based on above all, this study aims to find optimal route between the given POPs sites, either the shortest path between them or the route having minimum travel time and transposition cost. Three scenarios- one centralized POPs disposal center, one mobile facility for all the POPs sites and one centralized plant plus one mobile facility were simulated based on the ROUTE module available in Arc-GIS for the Road Network analysis and the resulting routes for various origin and destination points. The transposition distance and cost were also calculated for each of the scenario according to both the short-term case for only POPs stockpiles and the long-term case for the high polluted soil in order to supply a tool for decision making about disposal technology selection and waste transportation budget plan evaluation in the project preparation.

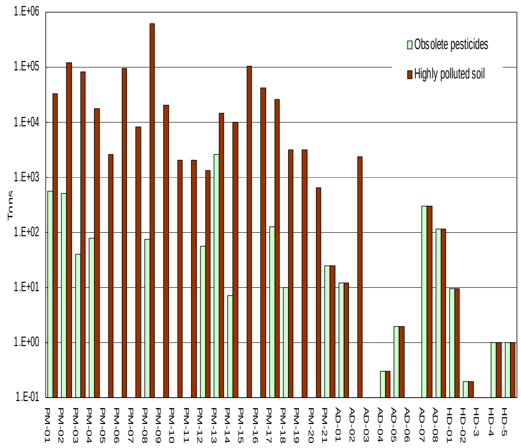
2. Materials and Methods

The Road Network Map of the study area is prepared using the 1:4,000,000 scale Topographic Database of the National Fundamental Geographic Information System of China (1:4,000,000 DB) in 2005, which consists of main rivers (level 5 and above), main roads, railways, cities (county and above), boundaries (county boundary and above) and the data are divided into 6 layers. The locations of obsolete POPs pesticide sites were identified by Google Earth. The actual implementation of the routing is process by the Network module within ArcPlot using the PATH or TOUR commands.
Network module is one of the most powerful analysis capabilities in ArcInfo for the path finding, or routing. It is not always an elementary task, however, to use the module for deriving or updating paths that are real-world solutions to various routing problems. Its successful use presumes the GIS specialist understands both the network data model and how it needs to be manipulated for each particular routing application. There are four components required in order to perform a routing task in the ArcInfo Network module. These elements are termed network links, network nodes, turns, and stops. Each of these elements will also possess attributes required in the routing process.

Fig. 1 shows the geographic distribution and the volume of stockpile and highly polluted for each site, where the amount of high polluted soil were calculated based on the average coefficient estimated from the actual monitoring and analysis results from the 4 (2 DDT, 1HCB and 1 chlordane) manufacturers for the soil with a contamination level above 50 ppm.



(a) Geographic distribution



(b) Site Status

Figure.1 Geographic distribution and site status of targeted obsolete POPs pesticides sites (PM- Pesticide Manufacturer, AD-Agriculture Department, HD-Healthcare Department)

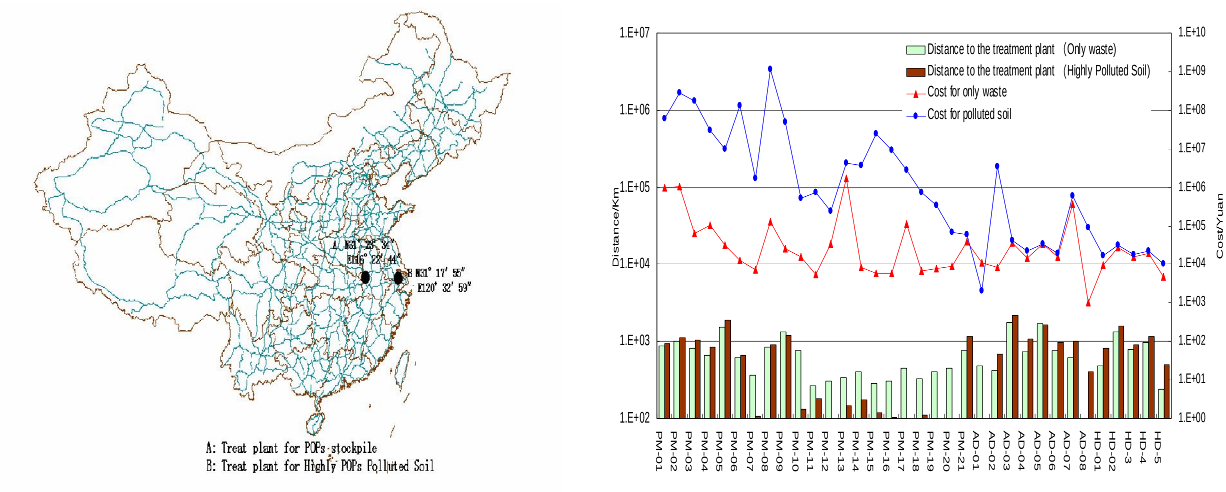
The optimal path is determined by finding the path with the lowest total for the arc directional impedance[5]. Furthermore, we also estimate the cost of transportation of the POPs pesticides and wastes by $C= L\times M \times 2$. Where, L the distance from a obsolete site to the treatment plant, M the amount of wastes in the sites and 2 is the unit cost with ￥/km · ton. The sites should be analyzed separately and not covered in the shortest rout find process, where has fewer obsolete POPs stockpile (<10 ton) or high polluted soil (<15 ton).

3. Results and Discussion

3.1 Scenario 1 – One Centralized POPs Disposal Center

In this scenario, one centralized disposal center would be installed for the treatment of all POPs pesticide stockpile and high polluted soil in the whole country, which is located by ArcGIS according to the nearest distance from all obsolete site to the treatment plant. Fig.2 (a) shows the location of the centralized disposal centers for stockpiles (Point A in Jiangsu provinces) and high polluted soil (Point B in Anhui province) according to the principle of shortest routs, respectively. It could be found the 2 suitable locations are both in the southeastern China for the pesticide stockpiles in a short term and the high polluted soil in a long term, because of most part of the stockpiles are just accumulated in this area.

Based on the above result, the distance and relevant transportation cost were calculated and shown in Fig.2 (b). The effectiveness of GIS based rout-finding was displayed in Fig.2(b), where the distance is lower than 100 kms and transportation cost is lower than RMB￥10,000 for most sites. Also, it is supposed that 10-ton and 15-ton waste collection vehicles be used for the transportation of POPs pesticide stockpiles and high polluted soil, so cost of those sites where has fewer obsolete pesticides and polluted soil would be calculated according to 10 and 15 tons respectively.



(a) Location of one centralized disposal center (b) The Distance and transportation cost

Figure 2. Location, distance and transportation cost for the scenario of one centralized POPs disposal center

It could be calculated that the total transportation cost is about RMB￥ 5 million. Fig.2(b) also tells us that the transportation cost for high polluted soil was much high than the obsolete stockpile and the transportation cost would be higher than RMB￥ 1.0×10^{9} for site PM-08 if all the highly polluted are transferred out. So, one centralized plant scenario might be not a cost-effective way for the disposal of large volume of polluted soil in a long term.

3.2 Scenario Two – One mobile facility for all the POPs sites

In this scenario, the disposal equipment is portable and the obsolete pesticides would be disposed in where they are, then the equipment is transported to next obsolete site. The advantage of this scenario is that the fewer transportation cost and lower environmental risk from the movement of large volume of obsolete pesticides and wastes when compared with to the first scenario. Table 1 shows the best rout and distance along the route. It could be calculated the transportation cost will be lower than RMB￥ 1 million even the mobile facility with a weight of about 100 tons.

However, the dismantling and re-installing cost is not ignorable, which might increase the transportation cost as high as dozen times. The re-installing cost for a semi-mobile Gas Phase Chemical Reduction (GPCR) facility is about US$ 750,000 (RMB￥ 168.3 million) that is so high and unacceptable in this scenario, when the facility would be dismantled and re-installed for 33 times. So, a lower re-installation cost is the prerequisite for the adoption of a mobile disposal facility.

Table 1. The best route and transportation distance for the scenario of one mobile facility

No.	Routs	Distance(km)	No.	Routs	Distance (km)
1	AD-3→PM-5	513	18	PM-6→AD-2	407
2	PM-5→HD-2	770	19	AD-2→PM-14	586
3	HD-2→HD-4	522	20	PM-14→PM-18	80
4	HD-4→AD-6	227	21	PM-18→PM-12	42
5	AD-6→HD-1	337	22	PM-12→PM-17	62
6	HD-1→AD-7	270	23	PM-17→PM-15	30
7	AD-7→PM-21	263	24	PM-15→PM-16	35
8	PM-21→AD-4	442	25	PM-16→PM-13	23
9	AD-4→PM-3	472	26	PM-13→PM-7	102
10	PM-3→PM-2	382	27	PM-7→PM-19	56
11	PM-2→AD-5	835	28	PM-19→PM-20	35
12	AD-5→PM-9	483	29	PM-20→AD-1	54
13	PM-9→PM-1	611	30	AD-1→PM-10	141
14	PM-1→PM-8	4	31	PM-10→PM-11	122
15	PM-8→HD-3	140	32	PM-11→AD-8	269
16	HD-3→PM-4	192	33	AD-8→HD-5	250
17	PM-4→PM-6	323	Total		9,075

3.3 Scenario Three – One centralized plant and one mobile facility

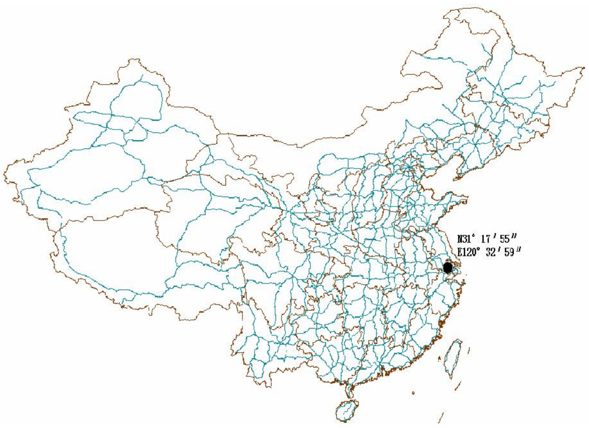
In this scenario, two disposal facilities- one centralized plant and one mobile facility will be installed and all obsolete POPs pesticides sites are divided into two parts. Most of the obsolete pesticide sites in the south of China will be disposed in a centralized plant, and the sites scattering in the north of China would be treated with a mobile faciltiy. As a result, we use the ArcGIS software to select one place according to the south part. Figure 3(a) shows the location. Then a treatment plant will be established in this place. But for the north part, we decide to adopt to treat the obsolete pesticides in the local sites using the mobile treatment equipment.

As we can see in Figure 3(a), the location of centralized POPs disposal center for south China is close to the location in scenario one, because most obsolete sites are just in the south, so the rest 5 sites(including PM1. PM2. PM8. PM9 and AD5) in the north have little influences on the treatment plant selection. Fig.3 (b) shows that the cost for transportation of POPs stockpiles and high polluted soil in the north China is about RMB￥ 2 million and 386.9 million, respectively. The transportation cost reduces distinctively when compared with scenario 1.

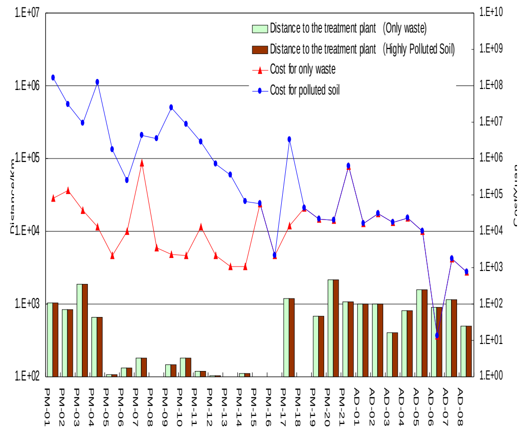
As for the sites in north China, a mobile facility will be adopted and the best route is PM8→PM1→PM2→PM9→AD5 with a distance of 1,372 kms. The transportation cost will be lower than RMB ￥ 140,000 even when the mobile facility with a weight of 100 tons. Moreover, only 4 movements will be needed and re-install cost will be controlled in this scenario.

4. Conclusion

In the point of view to attain a lower waste transportation cost, a centralized disposal center is not suitable for the treatment of large volume of high POPs-polluted soil, while re-installation cost should be considered fully for a mobile disposal facility.



(a) Location of the one centralized center



(b) Distance and transportation cost

Figure 3. Location, distance and transportation cost for the scenario of one centralized plus one mobile facility

5. Acknowledgements

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