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Monitoring of Asbestos in a Selected Latvian Area: GIS Based Risk Assessment

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Abstract—*Over decades, many studies were carried in the field of exposure assessment. Most of the time environmentalist makes new approach based on their research and work along with some facts and assumption to create a valid outcome of that work. Similarly, by considering some facts and assumption a risk assessment is made in one of Baltic country where asbestos is used highly. We have developed a GIS based risk assessment and monitoring plan for such location where asbestos is still in unattended form. Asbestos is a carcinogenic substance that hampers open environment and human life.*

The use of ArcGIS (Geographic information systems) along with indicators that were selected with local civil department guidance has been used to see the valuable output of research. The risk has been drawn in mapping using GIS and under 4-field classified modeling to see its effects within indicators used. As a result we developed a negative impact check listing in order to create a government and public action plan.

1. INTRODUCTION

Disasters are mostly results of the natural activities that are not specified by time and place. Some of such activities are due to minor seasonal changes but in some cases this changes makes some chemicals like asbestos to precipitates from the source surface and make them disperse in air to atmosphere which further effects human life when comes in contact. Colder weather with snow fall and heavy wind flow makes asbestos highly prone for eruption from surface and dispersion in open environment [3].

Asbestos is well known as thermo isolator substance. Few decades ago, asbestos was used highly in colder region like Northern Europe, Russia, US and UK due to low annual temperature and heavy snowfall. Using asbestos on the outer coating keeps internal temperature of house constant and protects from long winters. After the implementation of regulations to terminate the use and reuse of asbestos the older asbestos containing material (ACM) remains in unattended form in various sites. Many studies says that asbestos are very thin fiber structured that can fly in the air from few to more than 50 km. The use and reuse of asbestos is banned all over the world. As per the European Parliament (2012/2065(INI)), the disposal of asbestos has to be bought with the concept of End of Waste. Asbestos licensed firms are with specialized team that can take asbestos off from any open, damaged and renovation site.

Monitoring of the hazardous chemical with fine airborne particles is always been hard to do. For the first time a methodology has been approached to estimate the minimum risk and evaluate its effect using indicators along with tool ArcGIS. Further, mapping of risk and the creation of risk action plan as environmental protection act is obtained as final results [1,2]

The main aim of this research is to evaluate the possible risk dimensions that might occur to life and surrounding environment, and to create environment action plan accordingly. The set of indicators were selected with the help of local civil department of selected site Jelgava in Latvia. Further, the action and responsibility plan on public, government and environmental level has been set too.

2. SITE SELECTION AND RELATED CLIMATIC FACTOR

The most prominent factor responsible for asbestos fiber eruption from its surface is snow. The current research was carried in Jelgava region of Latvia where annual temperature is -8 degree Celsius with heavy snowfall. During some moment this temperature drops below -40 degree Celsius. When outer minor damage layer of asbestos comes in contact with snow, precipitation of asbestos occurs. Further to this, with high speed wind and rain which further makes fiber to travel from few till many kilometers. Some of such factors that are favorable to carry this research in Latvia are [4,10]:

2.1 Natural disasters

- Storms
- Whirlwinds
- Torrential rain and floods
- Snow storms and ice
- Snow drifts and ice dams
- Heat waves

2.2 Manmade Disasters

- Technogenic disaster
- Fire in the building
- Explosion
- Utilities and energy network bursting
- Collapse of buildings and structures.

3. ARCGIS MODELING

GIS has been evolved enough to be valuable part of multiple science stream research. This research gives one of the best examples of GIS use in the stream of environmental sciences. Using the data layers coordinate system the selected site that contains asbestos (ACM) can be marked and nearby region can be accessed which might be under risk of asbestos effect. By creating and using different layers in Arc-Tools we have arranged layers according to our need and priority.

GIS modeling is useful for displaying geographical data concern chemical contaminations, consumer risk area, locations of consumption advisors, population and place under dispersion coverage and more. Mapping and modeling by gathering data is helpful in every step of risk evaluation for asbestos like [5,6]:

- Display range of geographical area under Chemical dispersion coverage.
- Display population and density in the area of chemical effected concentration field.
- Display location of hazardous site exact on earth.
- Displays number of buildings under effected field.
- Determines the gap in terms of waste disposal site targeting with the best possibilities.
- Total population and number of houses in the city.

Though, due to the limited availability of ArcGIS data for selected country, many applications of GIS were not accessible which includes the factors like local natural resource monitoring and effects on them due to asbestos, recent constructed sites and water resource etc.

4. METHODOLOGY

To seek the possible risk related to the asbestos in open environment a fresh approach has been created from the base using the indicators based on the site condition and survey. Indicators are the statics used for the measurement of the current condition and the estimation of the related effecting factors on the environment. Indicators are the extensively used in the technical analysis of any research. The study is conducted based on indicators defined upon the region surveyed and estimated important factors that are mainly related to the human health effect and possible effected geographical area of asbestos dispersion. As per the World Summit on Sustainable development (WSSD), that adequate chemicals management based risk assessment should be achieved by 2020 to all around the world [6].

A systematic approach for methodology is going with a sequential flow to not only find risk but to prioritize the action plan required too. The methodology process initiates with:

- Determination of hazardous material
- Estimating the quality condition of material
- Marking the danger level by identifying the indicators
- Calculating total negative impact
- Prioritizing the action plan for removal of hazardous asbestos containing material (ACM)

Determination of this quality condition can be estimated as per survey with the experts and listing them according to the damage as critical> medium> lower with their respective effect. Following this, the negative impact check listing has been scored as -3>-2>-1 respectively [10].

Indicators that are used for this risk estimation and evaluation of methodologies applications in some important dimensions are:

- Hazardous determination
- Asbestos dispersion range (based on quality condition of ACM)
- Area of hazardous site
- Influenced sites
- Population density effect
- Natural sites and resource under risk

Whereas, the applications of these indicators were further measured under health, capacity, social and environmental dimensions as (Figure.1 and table.1):

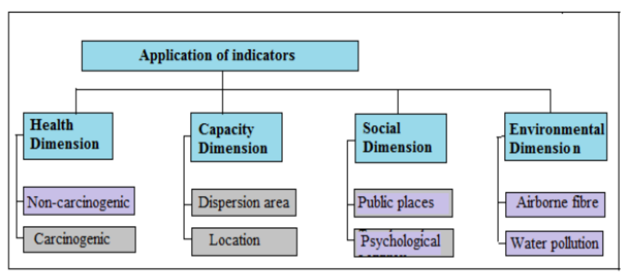

Fig. 1: Application of Indicators to analyze risk on various dimensions

Table 1: Applications of indicator in risk evaluation

Evaluation Dimension	Prospective of Evaluation	Evaluation Element		
		Hazard Assessment	Exposure assessment	Risk assessment
Health Dimension	Quantity	Range of asbestos in to cause its effect.	Breathing, sweat, smoking.	Mesothelioma, Epidemiologic al effect and lung cancer

	Quality	Type of asbestos used in house chrysotile (95% in building use) or amphibole [28].	Chrysotile – thin and smaller fibre with high exposure frequency.	More chances of causing Lung cancer.
	Duration	Smaller and thinner fibers in higher effective form	More frequent to exposed in environment with air flow variation	More frequent in causing Mesothelioma and lung cancer .
Capacity Dimension	Area of dispersion	Amount asbestos is higher in concentration field.	Higher amount in centre region and public place	Higher risk for life living nearby place
	Location	More hazardous near concentration field, hazard field and lesser in safety field	Exposure is higher near source of asbestos.	Higher chance of cancer in central part.
Social Dimension	Public access place	Dense populated central zone	Public university, library, church, kindergarten & apartment under exposure.	Lower risk of getting effect due to close place
	Ambient environment	Turning from primary source to secondary source of asbestos. [16]	Spreading due to temperature variation and wind flow	Higher amount in open atmosphere with natural activities like rain, temperature wind and other.
Environmental Dimension	Airborne fibre	Emission of hazard in open environment	higher change of infection	Higher risk for Mesothelioma and lung cancer.
	Water pollution	Further hazard carrier by water as carrier source	Further hazard carriage	Contamination of water resource

A *4field classified modeling* is proposed based on the selected site conditions (see figure.2). This modeling is to analyze the application of indicators and there study for negative impact check listing. Sites, where asbestos containing material is highly damaged and is always having higher effect on open environment. The defined fields estimate the fate of the pollutants in certain range from the main source of hazardous (ACM). The 4field classified modeling is defined as [7]:

4.1 Concentration Field [CF]

Concentration field is the area of site that consists of asbestos hazardous as main source (selected site).

With respect to the quality of the building as defined above in three different conditions in terms of quality the dispersion will be related directly to them as:

Dispersion range (DR) is directly proportional to the quality damage (QD).

$$DR \propto QD$$

4.2 Hazardous Field [HF]

This is the primary exposed field or field with higher concentration of asbestos exposure that is most near to the concentration field or infected site. This area is denoted with saffron color.

4.3 Warning Area/Safety Field

Area that is next to hazardous field where effect of asbestos is comparative lesser than hazardous field. Nevertheless, this field also might covers range of smaller amount of asbestos that can impact open environment and other life nearby. This field is denoted by light yellow color.

4.4 Precaution Field

The most outer or total range taken under study to cover the area of possible effected location for the mapping of risk map and further evaluation in GIS.

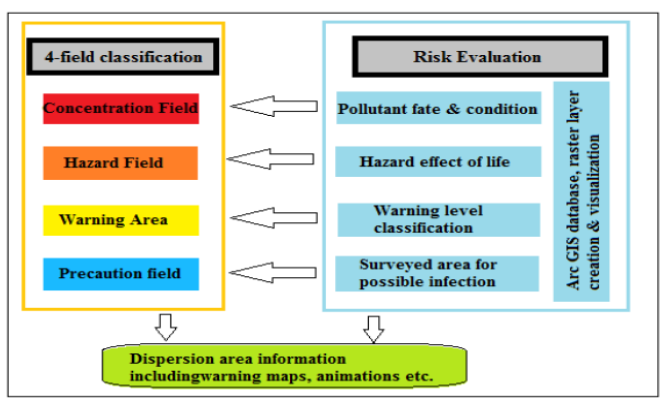

Fig. 2: 4Field classified model for risk evaluation method in Jelgava Region

Each mentioned field in this modeling has its own impact and related range effect. The range of each field is considered depending on the critical>medium>lower damaged condition of sites as defined before. Some of this impact can be accessed using GIS application is to know the total area occupied under hazardous effect, number of sites and population effect.

Further to this, the scale grading in negative impact check listing for the range of concentration field's effect of asbestos will be based on measurement as:

- Site with 0-150 m2 area is lower ranged contamination site consisting asbestos.
- Site with 150-300 m2 area is medium ranged contamination site in terms of asbestos concentration.
- Site with ≥ 300 m2 area is critical categorized range site in with high asbestos amount due to large area.

5. CASE STUDY

Example is drawn from environmental studies and emergency and risk planning to understand the impact of exposure of asbestos and customize risk assessment for same. This case has been implemented in Jelgava city of Latvia. Latvia is an Eastern European Baltic country that has heavy snow fall and high precipitation with moderate wind flow. The study has been conducted on selected eight sites in Jelgava region that have been listed by civil government for renovation and treatment. In other way, this study helped the local civil department for decision evaluation. As per the survey, the sites quality condition is listed as critical, medium and lower damage and marking has been done as -3, -2 and -1 respectively. The quality condition is estimated based on appearance of outer damage on roof, wall, piping with cement sheeting and total number of floors.

Accordingly, the risk measurement in the negative impact check listing can be kept as: C>M>L = -3>-2>-1. The impact is shown higher for a critical quality conditioned site. Similarly, labeling for other indicators in impact check listing like population and number of houses is done on the basis of density. Important and critical cases like presence of kindergartens, parks and major working places were also considered under types of sites which has maximum public access. The sum up of all indicators in the impact check list is done to get total negative impact of individual select site as (see table.2):

Table 2: Risk level estimation by negative impact check listing

Sr. No.	Site name	Sites under influence.	Quality of hazardous site	Sites type under effect	Population density effected	Area of site in m2	Total Negative impact
Checklist limit		0>100>150 >above	C>M>L	variable	0>500>1000 >above	0>100 >200 >above	
1	Vecpilsētas iela 14	-2	-3 + (-2)	-2	-3	-3	-15
2	Vecpilsētas iela 2	-2	-1 + (-2)	-2	-2	-3	-12
3	Vecpilsētas iela 10	-1	-2 +(-1)	-2	-2	-2	-10
4	Jāņa Asara iela 1	-1	-1 + 0	-3	-1	-1	-7
5	Jāņa Asara iela 10	-1	-1 + 0	-4	-1	-1	-8
6	Sakņudārza iela 7	-2	-1 + (-2)	-2	-2	-3	-12
7	Kazarmas iela 25	-3	-2 + (-1)	-4	-3	-3	-16
8	Garozes iela 3	-3	-2 + (-1)	-3	-3	-3	-15

Drawing the risk map using negative impact check listing and counting the impacted site, social life, open environment and total area under it shows the potential risk. Plotting this potential risk according to the negative check listing using ArcGIS can be seen as (see Fig. 3).

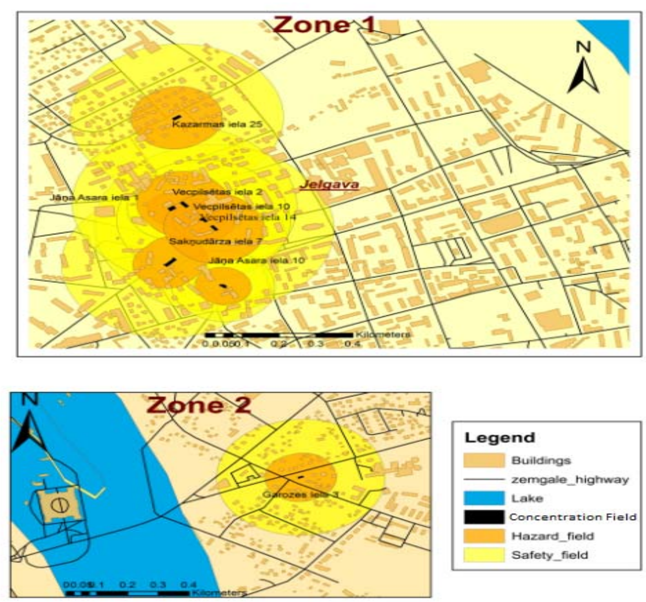

Fig. 3: ArcGIS based impact mapping of risk from individual selected sites in Jelgava.

5.1 Environmental Decision Evaluation

Most of the time with the check listing method some of decision based on environmental conditions was made by environmental experts where improper information and unorganized data is present. To organize the checklist strategy for any impact, following things needs to be kept under consideration [11]:

- Should be systematic in approach.
- Should be able to organize data in large scale.
- Should be able to evaluated and quantify the results.
- Prediction should be acceptable with good and strong assumption base.
- Should be capable of summarizing data.
- And finally, be able to display raw data and derived information in meaningful fashion.

Summing up the negative impact from individual indicators, we can see the highest and the lowest risky site. Referring to the negative impact check list (See table 2) we can see that site Kazarmas iela 25 is having highest impact with -16 grading due to high population density and presence of many public accessible sites. On the other hand site Jana Asara Iela 1 in having lower impact with -7 grading in impact check listing due to less population density.

The checklist method of EIA for any methodology brings the development projects with their advantages and disadvantages. More likely, this strategy also brings large decision making and a matter of choice for the judgement by analyst or specialist. Including this case where the final evaluation of methodology used for the assessment of risk which is helpful in making decision for the civil department of Jelgava region by take the action of treatment of site according to the priority [8,9,11].

6. CONCLUSION

For the first time a valid approach has been created on the scientific based proposal with all possible gathered data along with the local land government experts, literature and with the surveyed quality conditions. The integration of the strategy of approach with GIS and risk assessment creates an outline of the scenario for the probability of any disaster with addressing the major duties for different sectors for the immediate action with response plan as:

- Public level: To document the amount, place, type and time of asbestos use in house or any site.
- Government Level: To regulate the audit with expert and to keep all documentation related to asbestos use and removal including all information related to asbestos use. Also creating the public awareness plan for the possible effect of asbestos and other hazards. Most importantly, the prominent action required for hazard removal from the current case study according to the priority obtained with more detail research plan in the region is required.
- Environmental response level: Documentation of detail of site containing asbestos with the proper disposal and use of best available technique for taking care of material. More importantly the proposed sequence according to the priority in environmental negative impact check listing is the most important outcome for the Jelgava city building department. This helps the specialist and expertise to take decision for taking the site down or treating it accordingly.

Whereas, certain limitations like unavailability of Latvian GIS data, under consideration of climatic factor and unwillingness of public participation in study might gives a gap for further research. But on the other hand this GIS based research in general also provides a National emergency risk plan that can be implemented during any disaster like chemical spill or flood case to prepare evcuation.

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