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Mapping of mercury pollution in GIS-based small-scale mining (case study: Cineam Tasikmalaya District)

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Abstract. The use of mercury in Small Scale Gold Mining (ASGM) in Cineam District, Tasikmalaya Regency is one of the most important problems in the environment. The long-term accumulation of mercury use results in uncontrolled and invisible mercury pollution. This threatens the health of the environment and has a very bad impact on humans in the long run. Geographical Information System is one way to map and record mercury pollution in Cineam District. The creation of a web-based GIS application can automatically display the mercury pollution distribution radius in the area around the Cineam District ASGM Tasikmalaya District.

1. Introduction

Small-Scale Gold Mining (ASGM) in Indonesia or commonly referred to as Gold Small Scale Mining (GSM) are numerous and difficult to detect their existence. In 2010, around 280 tons of illegal mercury were imported into Indonesia for use in ASGM. This figure has doubled in 2011 [1]. In the process, traditional gold processing (amalgamation) produces mining industry waste (tailings) [2]. Tailings are mercury wastes which increase every time along with mining activities. Mercury is a chemical widely used by large-scale gold miners and Small-Scale Gold miners (ASGM). The majority of researchers agree that mercury use provides greater losses than the results obtained from ASGM [3]. In accordance with regulations the threshold for safe concentration of mercury (Hg) is only allowed 0.001 ppm (President of Republic of Indonesia No. 28 of 2001 and Decree of the State Minister of Environment No. 112 of 2013) [4].

According to the United Nations Environment Program (UNEP) Global Mercury Assessment. Who found that mercury is found in fish worldwide at levels that harm humans and animals [5]. In humans, hair is generally accepted as a means of estimating the body's methyl mercury load, which is most likely derived from fish consumption [2,6], however mercury is useful for industrial purposes such as making batteries, cellulose and plastics, pharmaceuticals, paints, and laboratory and electronic equipment. In water, mercury can spread on the surface, or settle on sediments.

The Cinema Area of Tasikmalaya Regency has many ASGM and the number is difficult to know, because it operates in a hidden and far from monitoring from the local government. The ASGM has been in operation for a long time and has been gradually decreasing natural resource mining in the form of gold. Excavation of land and logging of forests and the use of mercury in a negative impact, not only on the environment, but also on humans around the mining area. This is often not recognized by the



general public, because mercury does not directly show its impact but slowly but surely. Nonetheless, the existence of ASGM is difficult to control because ASGM is a source of income for the local community which has been carried out for a long time.

Information technology has been widely used for the benefit of humans, one of the technologies often carried out in the interest of knowing environmental changes. Is a Geographic Information System (GIS), of course it will be useful if it is used for mapping pollution due to the use of mercury around ASGM to provide a clear and comprehensive picture of the distribution of mercury map-based pollution with web technology. The method of making web-based GIS applications intended for mercury pollution mapping uses the V-Mode method with the approach of the object oriented process (OOP) paradigm.

2. Theoretical Basis

2.1. Mercury

Mercury pollution is one of the most important problems in the environment [2]. Mercury at certain concentrations can cause death and health problems that cannot recover in a short time [7].

2.2. Mapping

Mapping is grouping a collection of regions that are related to some geographical location of the region which includes the highlands, mountains, resources and potential of the population that influence the socio-cultural which has special characteristics in the use of appropriate scale [4].

Another definition of mapping is a step that must be done in making maps. The initial steps taken in making data, followed by processing data, and presenting in the form of maps [8].

So, from the two definitions above and adapted to this research, mapping is the process of collecting data to be used as a first step in map making, by describing the spread of certain natural conditions in a spatial manner, moving the real situation into a base map, expressed by using a map scale.

2.3. Geographic Information System

Geographic Information Systems (GIS) always develop, increase, and vary. Geographical Information Systems (GIS) is also a field of study of science and technology that is relatively new, used by various fields of disciplines, and is developing rapidly. Geographical Information Systems (GIS) are organized collections of computer hardware, software, geographic data and personnel that are designed efficiently to obtain, store, update, manipulate, analyze and display all forms of information that are geographic in reference.

Geographical Information System (GIS) is a set of tools that allows processing of spatial data into information in assisting policy making about the earth. The Geographical Information System (GIS) is composed of the concepts of several layers and relations [9].

2.4. Google map

Google Maps is an online map application service provided by Google for free. The Google Maps map service is officially accessible through the site <http://maps.google.com>. On the site, geographical information can be seen on almost all surfaces on the earth except the north and south poles. This service is made very interactive, because in it the map can be shifted according to the user's wishes, change the zoom level, and change the appearance of the map type.

Google Maps has many facilities that can be used for example location search by entering keywords, the intended keywords such as the name of the place, city, or road, other facilities namely calculating travel routes from one place to another [1].

3. Methodology

System development methods used during the research using the Rational Unified Process (RUP) method. RUP uses the object oriented concept, with activities that focus on developing models using the Unified Model Language (UML). Through the picture below it can be seen that RUP has, namely:

1. The first dimension is drawn horizontally. This dimension represents the dynamic aspects of software development. This aspect is described in the development phase or phase. Each phase will have a major milestone that marks the end of the next phase. Each phase can stand from one iteration. This dimension consists of Inception, Elaboration, Construction, and Transition.
2. The second dimension is described vertically. These dimensions represent the static aspects of the software development process which are grouped into several disciplines. The software development process described in several disciplines consists of four important elements, namely who is doing, what, how and when. This dimension consists of Business Modeling, Requirement, Analysis and Design, Implementation, Test, Deployment, Configuration and Change Management, Project Management, Environment.

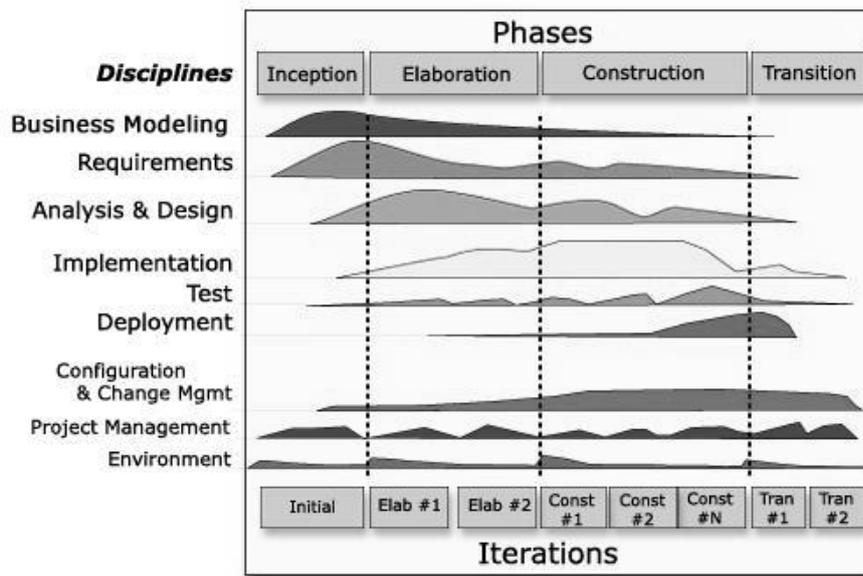


Figure 1. Rational Unified Process Architecture

Source: Pressman [9]

The application creation phase uses the RUP method as follows:

1. Inception, namely determining the scope of the project, creating a 'Business Case', answering the question 'what is done can create a' good business sense 'so that the project can be continued.
2. Elaboration, that is analyzing various requirements and risks then setting the base line.
3. Construction, that is doing a series of iterations, in each iteration will involve the following processes: analysis of design, implementation and testing.
4. Transition, namely making what has been modeled into a finished product, in this phase beta and performance testing are carried out, making additional documentation such as; training, user guides and sales kits, plan product launches to the user community.

3.1. 5W + 1H method

The research method used for mapping the distribution of pollution around PESK uses the 5W + 1H approach. The 5W + 1H method is used to formulate problems and solutions related to pollution in the ASGM operational area. The problem approach mechanism uses the 5W + 1H method as shown in Figure 3.2 below:

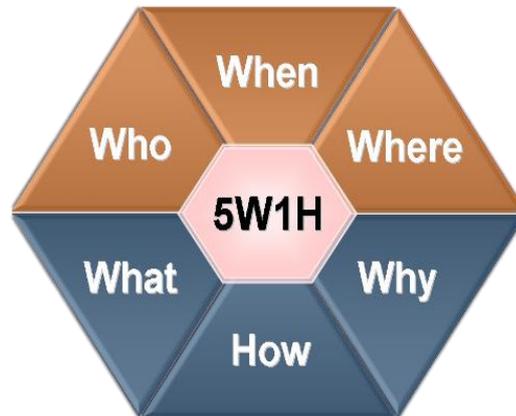


Figure 2. 5W1H Method

<i>Step</i>	<i>Action</i>
<i>Where</i>	Identifying the location, namely in the area around the Cineam District ASGM of Tasikmalaya District
<i>What</i>	<ul style="list-style-type: none"> • The material analyzed from this study is the distribution of pollution of heavy metals, namely mercury in the area around ASGM. • The technology that will be applied is web technology • The scientific field needed in this study is the science of Public Health or the Environment and information technology
<i>Why</i>	<ul style="list-style-type: none"> • Mercury is a substance that is harmful to ecosystems, especially humans, because in the long run it can cause fetal disability and human genetic disorders. • Mercury causes negative effects that are not felt by humans • Mercury distribution in the environment cannot be seen in plain view, so GIS technology helps in knowing the distribution of mercury pollution. • Mapping of mercury pollution in the area around ASGM is important to help the community, government and researchers know the extent of the distribution of environmental pollution as a result of GIS-based ASGM. • Ministry regulations regarding the environment and pollution from heavy metals in the mining environment.
<i>Who</i>	<ul style="list-style-type: none"> • Identify who is the user of the pollution mapping application, Who is the miner. • Analysis based on 5M (Man / Manpower, Machine, Material, Method, Mother Nature (work environment).
<i>When</i>	<ul style="list-style-type: none"> • Identify how long the ASGM has been operating and when problems have occurred to the community around ASGM. • The extent of distribution of mercury pollution in water and sediment.
<i>How</i>	<ul style="list-style-type: none"> • Taking water and soil samples (sediments) along with spot coordinates for sampling is done in stages • Phase I is carried out by the closest part (radius <50 m) from ASGM. Phase II surveys are taken samples with a radius of 100 m from ASGM and a 200m radius sample is carried out in stage III. • Analyze mercury levels in water and sediment using the irradiation process in the laboratory • Coordinate data from samples and lab results from samples are converted into spatial data to be displayed on GIS • Designing and Making a GIS application using a web-based RUP method • Dissemination to the public about mercury hazards to communities around ASGM.

4. Results And Discussion

4.1. Software Implementation

This section shows the results of interface design that has been implemented into a program created using PHP with the database used is MySQL.

1. Main page

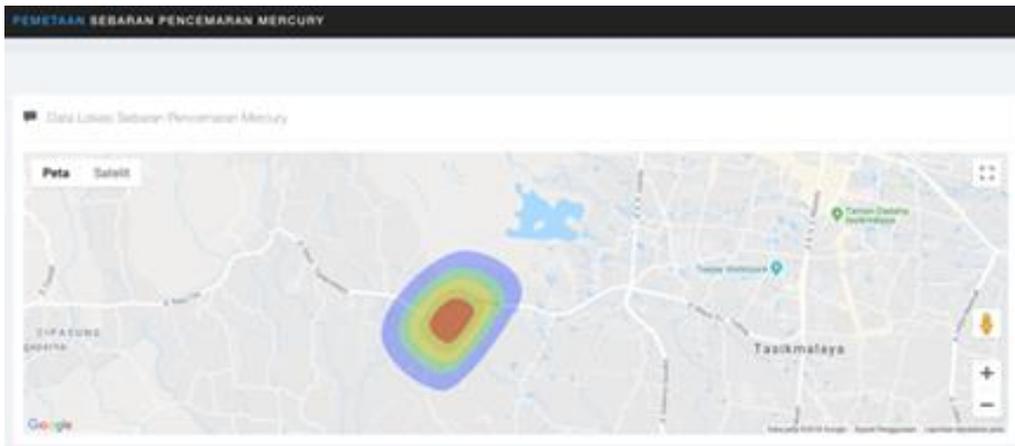


Figure 3. Main Page

On this page you can see the point and area of mining and the spread of mercury in certain locations.

2. Data Input Page

No	Nama Penambangan	Alamat	Aksi
1	PESK Cineam	Cineam, Tasikmalaya, Jawa Barat	

Figure 4. Data Input Page

On this page you can enter the location data points that have been obtained, so that the location point of PEST and the distribution of pollution will also appear on the main page.

3. ASGM Location Page

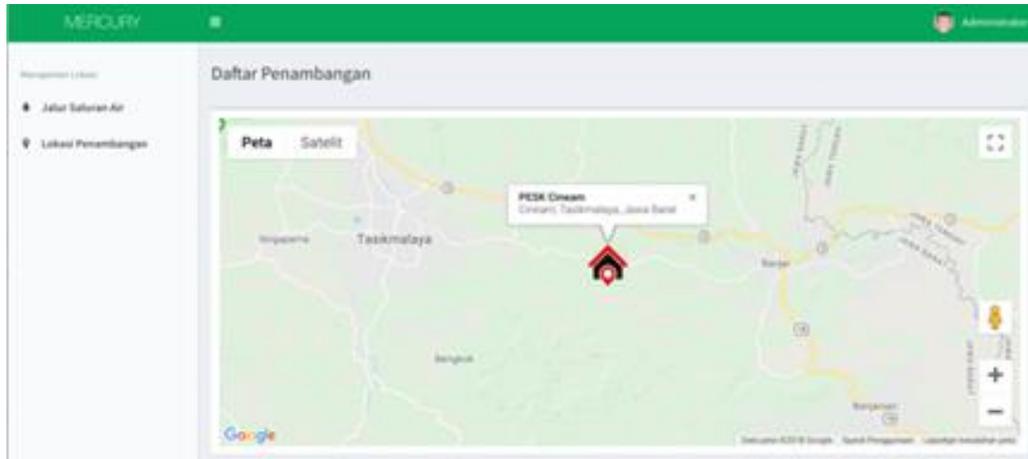


Figure 5. ASGM Location Page

On this page you can see the location points for Cineam sub-district of Tasikmalaya District.

4.2. Advantages and disadvantages

The advantages of this application are as follows:

1. In this application it can show the distribution of ASGM location points, mark the point of pollution and store it in the database.
2. In this application data will appear in the form of markers with layer level in accordance with the level of pollution in the field.

Deficiency :

1. Display the map and location point must be online.
2. The application only covers points located in Cineam District, Tasikmalaya Regency.

5. Conclusions And Suggestions

5.1. Conclusion

Based on the results of the research that has been done can be concluded as follows:

1. Geographical information system mapping the distribution of mercury pollution in Cineam Subdistrict, Tasikmalaya Regency can be used as one of the information media regarding location points and locations in Tasikmalaya Regency.
2. Geographical information system mapping the distribution of mercury pollution can display information about the location and point of pollution at the layer level according to the level of pollution in the field.

5.2. Suggestion

In this study, of course there are many shortcomings found, so suggestions can be given if they can be used and support as a reference for the next system development. Geographical information system mapping the distribution of mercury pollution can still be developed in the future. There are some drawbacks to the features found in the geographic information system mapping the distribution of mercury pollution, which include, in the absence of the nearest road route displayed in the geographical information system mapping the distribution of mercury pollution, the study only covers mercury pollution in Tasikmalaya.

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