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SOUND LEVEL MAPPING USING GEOGRAPHIC INFORMATION SYSTEM (GIS) TO OPTIMIZE A GREEN CAMPUS ENVIRONMENT QUALITY

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ABSTRACT

Universitas Gadjah Mada (UGM) is aiming to be a university that leads dissemination of application of energy conservation principles with its Green Campus concept. One of Green Campus concepts is the green behaviour by giving information and inviting citizens to use energy, water and paper efficiently and giving education to citizens about environmental issues. One of the examples in energy efficiency practice is car-free streets. Energy consumption can be shown by number of vehicles and number of vehicles can be shown by sound level comparison or sound level mapping. Sound level mapping is a graphic representation of the sound level distribution existing in a given region, for a defined period. The higher sound level indicates more vehicle pass through an area. Number of vehicles and limited street capacities create traffic jam frequently. During a traffic jam, vehicle burn fuel but not moving and cause bad effect to environment. Sound level mapping is needed to know how big the effect of sound level to environment quality. Optimizing environment quality can be made by giving suitable recommendation based on sound level mapping. In this research, sound level mapping is conducted using Geographic Information System (GIS). GIS integrates five key components: hardware, software, data, people and methods. Universitas Gadjah Mada is selected as the research location due to the large amount of vehicles used by students and the areas intersect with public spaces. Data were collected in five areas which have intersections with public spaces such as hospital, shopping center, worship place, food court, and main road. Measurement points will be given for each area. Sound level data is processed using signal processing software, Adobe Audition CS6, then processed using mapping software, Surfer 11.0. This sound level mapping linked with traffic volume data for each street in UGM. Based on sound level mapping, maximum percentage of white acoustic zone for each area is only 18%. Meanwhile, most of the areas are black acoustic zone with sound level over 65 dB(A).

Keywords: sound level, sound level mapping, geographic information system, traffic volume, landscape element, institutional area, public space.

INTRODUCTION

Universitas Gadjah Mada (UGM) is aiming to be a university that leads dissemination of application of energy conservation's principle with its Green Campus concept. The concept includes aspect in Green Building, Green Place and Green Behaviour. Green building can be reached with energy saving, less CO_2 emission and recycle-reuse of waste and high indoor air quality. Green place can be reached with healthy learning facilities, green space, water infiltration, reduce vehicle pollution and easy access for mass transportation. Green behaviour can be reached by giving information and inviting citizens to use energy, water and paper efficiently and giving education to citizens given the environmental issues.

One of example of use energy efficiently is car-free street. Total energy use of vehicles depends on total of vehicle itself. More vehicles cause more energy consumption. Traffic volume data that already available is total traffic volume of each province or city. Especially for UGM areas, collecting traffic volume data has been done by students of urban planning and diploma civil of engineering. However, data is still sporadic or spreads for each street.

Besides that, there exist certain criteria in order to achieve a green campus condition as related to noise level exposure, approximately not exceeding 65 dB(A). Distribution of noise level in UGM can be shown by sound level mapping.

Sound level mapping concept has been developed for a long time and a lot of research has been done in some countries in Europe since 25 years ago. Kang-Ting Tsai *et al* [1] explain that measurement of sound level which he did in Tainan city, Taiwan has been done at three times, in the morning (08.00 – 10.00), afternoon (14.00 – 16.00) and night (20.00 – 22.00) in summer and winter. Tara P McAlexander *et al* [2] argue that measurement can only be done on weekdays, Monday to Friday, to avoid significant traffic noise and different activity pattern between weekdays and weekends. In Indonesia, sound level mapping in educational area has been done by Rais Ridwan Maulana *et al* [3] in Politeknik Elektronika Negeri Surabaya (PENS). Collecting data made in the morning (09.00), afternoon (12.00) and evening (15.00).

Method for sound level mapping, in this research, is Geographic Information System (GIS). GIS is a computer-based tool that analyzes, stores, manipulates and visualizes geographic information on a map. GIS integrates five key components: hardware, software, data, people and methods [4]. By using GIS, we can overlap

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sound level mapping of each area with traffic volume data for each street.

METHODOLOGY

Determining location measurement

Location measurement of this research is UGM areas which adjacent with public space like hospital, shopping center, worship place, food court and main road. Table-1 shows distribution of location measurement. Furthermore, measurement point determined for each area shown at Figure-1

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Table-1. Measurement location.

No	Area	UGM area which adjacent with public space
1	Hospital (RSUP Dr. Sardjito)	Faculty of Engineering and Medicine
2	Shopping Center (Mirota Kampus)	Faculty of Science
3	Worship Place (Mosque of UGM)	Faculty of Psychology and Diploma of Economy
4	Food Court (BNI UGM Foodpark)	Faculty of Law
5	Main Road (Intersection of MM UGM)	Post Graduate of Management Building

Figure-1. Measurement points.

Observation of measurement instrument

We need to understand how measurement instrument like hand-held analyzer H6 Zoom brand works. In this section, standard operational procedure (SOP) created.

Figure-2. Measurement instrument: H6 Handy recorder [5].

Collecting data

Collecting data has been done in three times , in the morning (06.30 – 08.30), afternoon (11.00 – 13.00) and evening (15.30 – 17.30). Collecting data focused on weekdays with duration 4 minutes for each measurement points.

Manipulated data

After all data collected, data ready to processed. Data from H6 Zoom hand-held analyzer is file with .wav extension. This file must be modified with signal processing software until it can be read in decibel scale (dB(A)), sound level unit. The value of sound level mapped with the result is sound level mapping for each area.

Recommendation

By sound level mapping for each area, recommendation will be given on that area to avoid acoustics problem. Furthermore, with traffic volume data, recommendation will be given to energy consumption problems.

RESULTS AND DISCUSSIONS

Sound level data in five areas collected since March 2nd to April 29th 2015. Several times, collecting data has a problem with weather. If rainy, data cannot collected. Data manipulated until it can read in dB(A), or sound level unit, for each point with Adobe Audition CS6, Microsoft Excel and Surfer 11.0. In Adobe Audition CS6, frequency analysis is given for all data and yield sound level in dB. Furthermore, data calculated with A weighting factor to bring in dB(A) by Microsoft Excel. The value of sound level mapped by Surfer 11.0, with color scale shown at Figure-3, and creates sound level mapping for each areas in Figure-4, Figure-5 and Figure-6 for morning time, noon and evening, respectively.

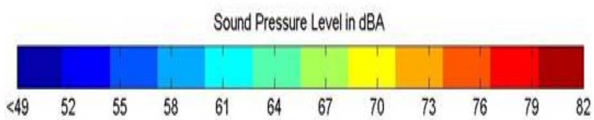
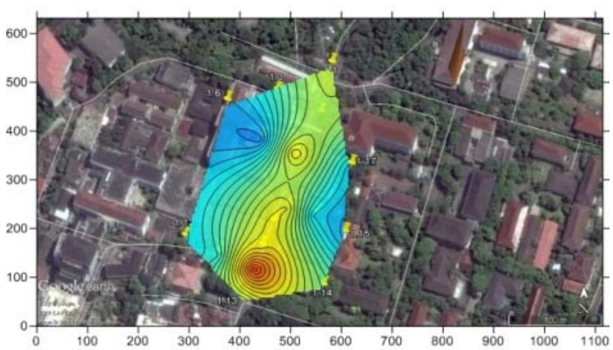
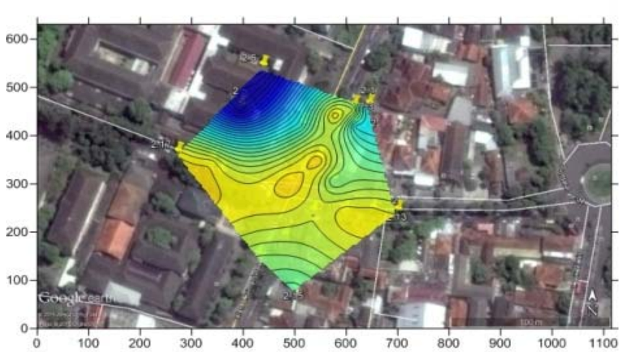


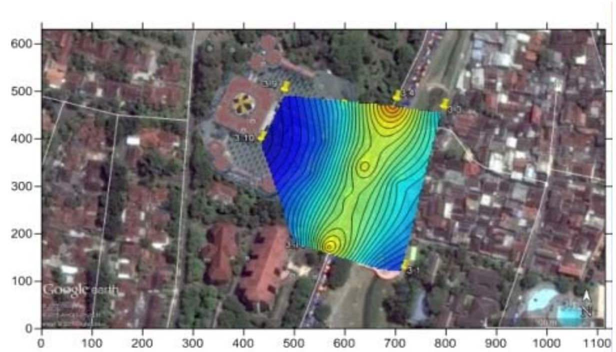
Figure-3. Color scale of sound pressure level in dB(A) [6].



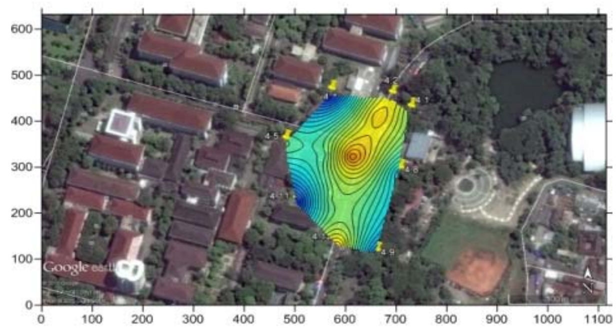
Hospital



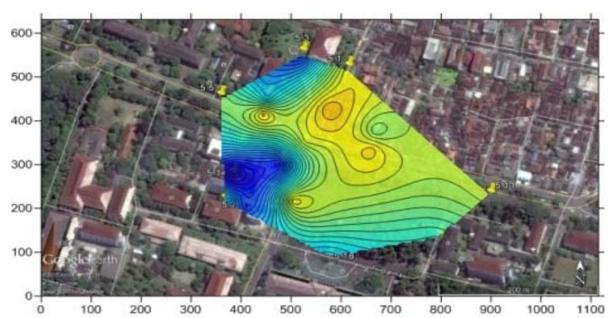
Shopping center



Worship place

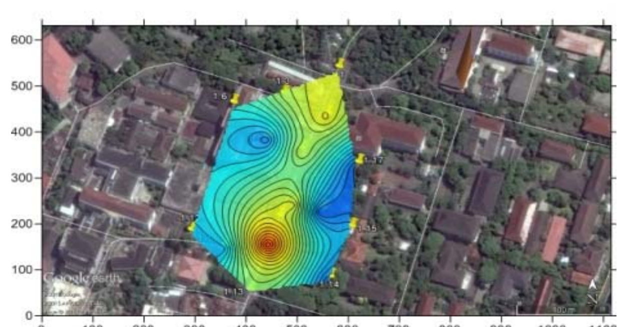


Food court



Main road

Figure-4. Sound level mapping for each areas in the morning.



Hospital

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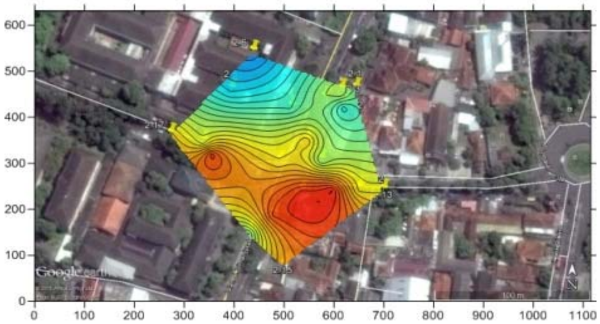
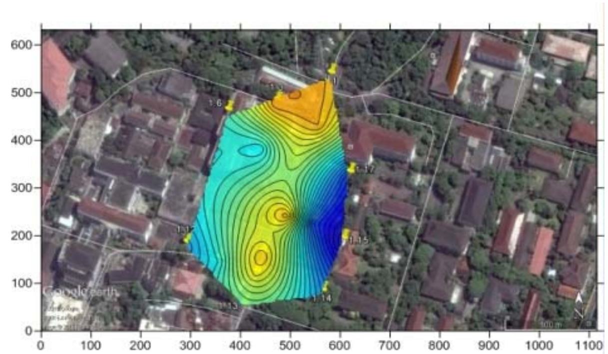
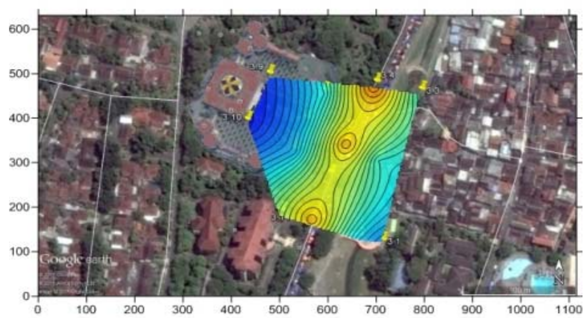


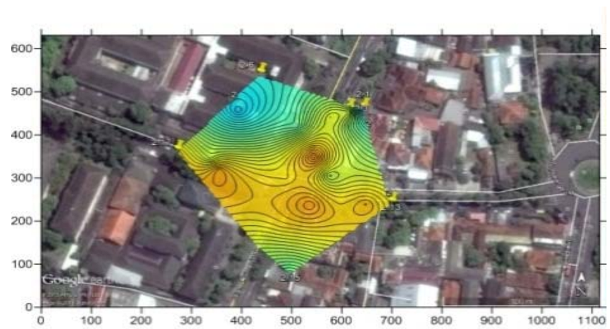
Shopping center



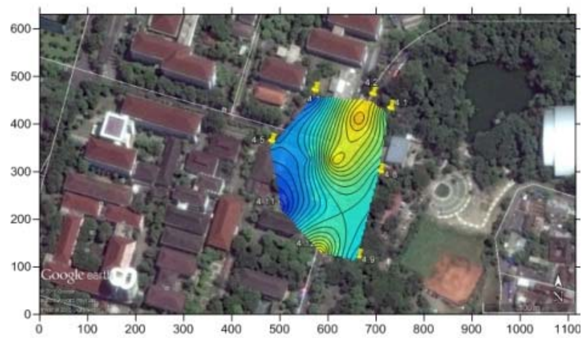
Hospital



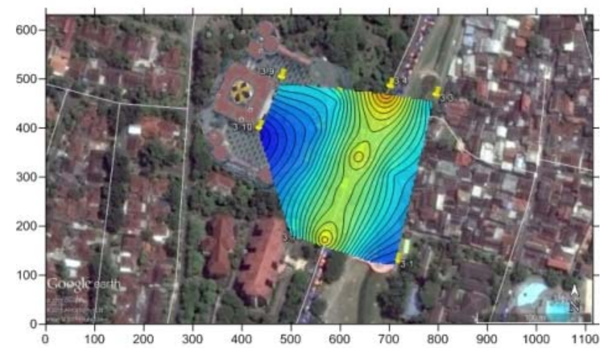
Worship place



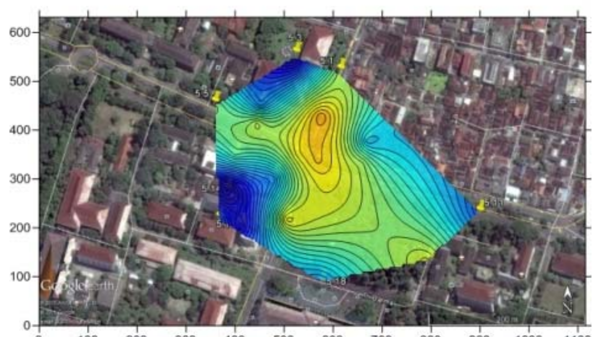
Shopping center



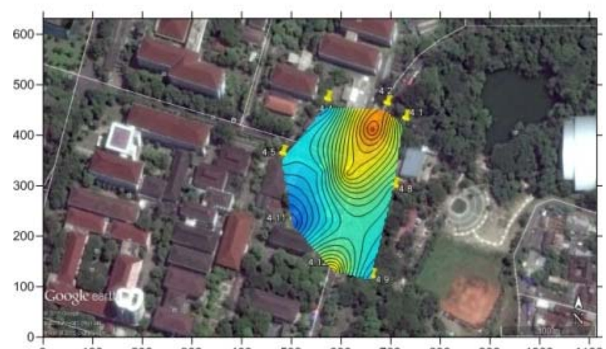
Food court



Worship place

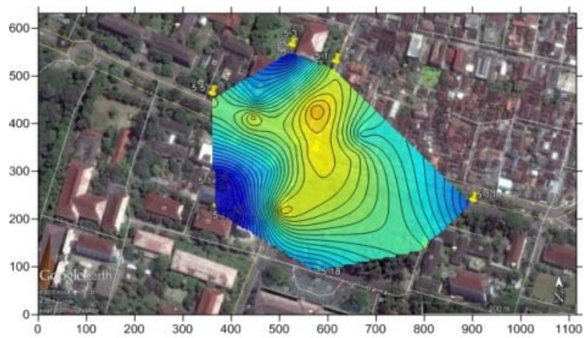


Main road



Food court

Figure-5. Sound level mapping for each areas in the noon.



Main road

Figure-6. Sound level mapping for each areas in the evening.

By sound level mapping, we know distribution of high noise level which in the morning sound level lower than in the noon and evening. The highest noise level occur in the shopping centre especially at parking lot in the noon. It reached about 79 dB(A). Recommendation is given to reduce high sound level, for example is adding vegetation that could be a barrier for noise.

Organization for Economic Cooperation and Development (OECD) tells about black, grey and white acoustic zone. Black acoustic zone is zone with sound level over 65 dB(A), grey acoustic zone is zone with sound level between 55 – 65 dB(A) and white acoustic zone is zone with sound level under 55 dB(A). Based on sound level mapping for each area, classification of acoustic zone shown at Table-2 and give a conclusion that only 18% (maximum) of total area are white acoustic zone.

Table-2. Acoustic zone classification.

Area	Time	Acoustic Zone		
		White	Grey	Black
Hospital	Morning	0 %	50 %	50 %
	Noon	0 %	50 %	50 %
	Evening	5 %	45 %	50 %
Shopping center	Morning	8 %	25 %	67 %
	Noon	0 %	17 %	83 %
	Evening	0 %	17 %	83 %
Worship place	Morning	18 %	48 %	34 %
	Noon	5 %	45 %	50 %
	Evening	5 %	62 %	33 %
Food court	Morning	1 %	49 %	50 %
	Noon	1 %	62 %	37 %
	Evening	1 %	57 %	42 %
Main road	Morning	5 %	58 %	37 %
	Noon	7 %	43 %	50 %
	Evening	5 %	45 %	50 %

Furthermore, sound level mapping is overlapped with traffic volume data for each street which is described in Figure-7. From this overlap, we obtain relation between sound level and traffic volume shown at Table-3. Traffic volume data consist of personal vehicles and mass transportation with dominant of personal vehicles. Fewer vehicles have lower sound level, and more vehicles have higher sound level. However, it does not linear. There are some another factors which had an effect on sound level such as existence of vegetation and building.

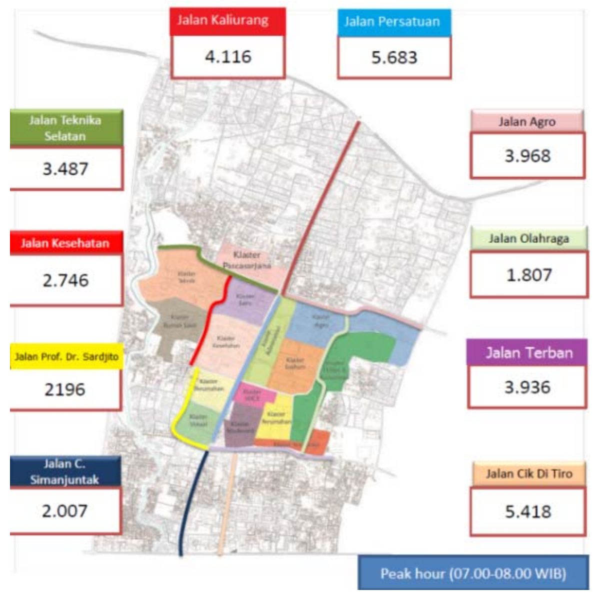


Figure-7. Traffic volume in UGM [7].

Table-3. Comparison of sound level and traffic volume.

No	Street	Traffic volume	Sound level (dB(A))
1	Jl. Olah Raga	1.807	67,32
2	Jl. C. Simanjuntak	2.007	68,21
3	Jl. Prof. Dr. Sardjito	2.196	70,62
4	Jl. Kesehatan	2.746	70,1
5	Jl. Teknika Selatan	3.487	66,85
6	Jl. Terban	3.936	69,99
7	Jl. Agro	3.968	71,66
8	Jl. Kaliurang	4.116	70,64
9	Jl. Persatuan	5.683	71,92

If we know landscape condition of a certain area, this sound level mapping still could be used to describe traffic volume for each street. This traffic volume can be split based on type of vehicle shown at Table-4 and can predicted energy consumption with assumption shown at Figure-8 with the result in Table-5.

Table-4. Traffic volume based on type of vehicle.

No	Street	HV	LV	MC	UM	Total
1	Jl. Olah Raga	10	461	1.314	22	1.807
2	Jl. C. Simanjuntak	11	512	1.460	25	2.007
3	Jl. Prof. Dr. Sardjito	12	560	1.597	27	2.196
4	Jl. Kesehatan	15	700	1.997	34	2.746
5	Jl. Teknika Selatan	19	889	2.536	43	3.487
6	Jl. Terban	21	1.004	2863	48	3.936
7	Jl. Agro	21	1.012	2886	49	3.968
8	Jl. Kaliurang	22	1.050	2.993	51	4.116
9	Jl. Persatuan	30	1.450	4.133	70	5.683

Figure-8. Energy consumption for each vehicle [8].

Table-5. Energy consumption for all vehicle.

No	Street	Traffic volume	Energy consumption (lt/km)
1	Jl. Olah Raga	1.807	68,63
2	Jl. C. Simanjuntak	2.007	76,22
3	Jl. Prof. Dr. Sardjito	2.196	83,40
4	Jl. Kesehatan	2.746	104,29
5	Jl. Teknika Selatan	3.487	132,43
6	Jl. Terban	3.936	149,48
7	Jl. Agro	3.968	150,70
8	Jl. Kaliurang	4.116	156,32
9	Jl. Persatuan	5.683	215,83

Based on Table-5, the more traffic volume will cause more energy consumption. For the future, this research could be developed into real time. There will be a monitor that shows sound level mapping and estimated traffic volume in a certain area and also its energy consumption. The next research will also explore relation of sound level, vegetation and environment quality.

CONCLUSIONS

Based on sound level mapping, maximum percentage of white acoustic zone for each area is only 18% that shown in worship place in the morning. Most of total area are black acoustic zone with sound level over 65 dB(A).

Traffic jams not only cause air pollution and noise but also energy emission so regulation for vehicle pathways, especially for vehicle with low energy efficiency, is required. From sound level and landscape of certain area, we can predicted traffic volume, and by the traffic volume we can predicted energy consumption for vehicle. Less vehicle, less energy consumption. Procurement of mass transportation and bicycle in university campus is needed. Developing sound level mapping using the integrated tools and real-time monitoring could monitor noise, traffic jam of the city and energy consumption of vehicle.

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