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Correlation Between Settlement Environmental Quality and Acute Respiratory Infection (ARI) Disease of Gayamsari Sub-District, Semarang

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Abstract

Settlement area with high population density and situated in unfeasible location cause the quality of settlement environment to be low. The low quality of settlement environment has the potential to cause Acute Respiratory Infection (ARI). This study aimed to explain the correlation of settlement environmental quality and incidence of ARI disease in Gayamsari Sub-District, Semarang. This research used a quantitative descriptive spatial approach by using remote sensing technique and Geographic Information System (GIS). The result showed that there is a high and significant correlation between settlement environmental quality and acute respiratory infection (ARI) Incidence, especially happened in Kaligawe and Tambakrejo village.

1. Introduction

High urban population growth has an impact on increasing demand for settlement area. Opportunities to improve living standards, close to the center of the economy, good access to public facilities, and the availability of land that can be converted, become a pull factor for population growth in urban areas (Ambarasakti, 2013; Dewi et al., 2016). While the dominant factor affecting settlements growth is accessibility, infrastructure completeness, and workplace (Pigawati et al., 2018). China Predicts the settlement growth in area with high economic growth will increase land use conversion, especially on conservation area (Yang et al., 2019). Discussion of settlement area as human habitation includes the quantity and quality because it is related to the welfare and the comfortless of its inhabitants (Pigawati et al., 2019). Meanwhile the meaning of settlement environment is condition of housing quality , infrastructure supporting, as well as people and their behavior (Ayuningtyas & Pigawati, 2018; Istikasari & Khadiyanto, 2014; Rahardjo, 1989).

Limited proper settlement land in urban area causes residents to live in areas that are not feasible, do not meet the requirements to be used as residential areas. This condition is one of the problems that causes a decline in the settlement environmental quality. The decline in the settlement quality that occurred in Ghana, Africa is caused by increased urbanization and infrastructure requirements that are not fulfilled (Fiadzo et al., 2001). The decline of settlement environmental quality in Nigeria can be identified spatially, using parameters such as types of building units, floor quality, walls quality, and roof of buildings, availability to clean water and sanitation (Morenikeji et al., 2017). Settlement environmental quality can be identified spatially utilizing geographic information systems by analyzing the parameters that appear through satellite imagery including settlement density, building arrangement, road width, road conditions, green area/vegetation, and settlement location (Ekartaji et al., 2016; Pigawati et al., 2019; Priyono et al., 2013).

The condition of the house and its environment that do not meet health requirements, make the risk factors for the development of several types of environmental-based diseases including diarrhea, cholera, dysentery, DHF, intestinal worms or respiratory disorders such as asthma, tuberculosis, and ARI) (Keman, 2005). Different qualities of housing and settlements will provide different respiratory health outcomes (Gan et al., 2017; Lévesque et al., 2018). The behavior of people who live in unfeasible settlement areas is one of the factors that influence the ARI (Sahana et al., 2018). ARI is upper or lower respiratory tract disease, usually contagious, which can cause a variety of diseases ranging from asymptomatic or mild infections to severe and deadly diseases, depending on the causative pathogen, environmental factors, and host factor (World Health Organization, 2003). ARI sufferer are dominant visitors who come for treatment at health service facilities (Puskesmas), especially in the child care department. Factors that influence the spread of ARI are environmental conditions which among others are related to air pollutants, density of family members, humidity, cleanliness, season, temperature.

Gayamsari Sub-district, located in the northern part of Semarang City, and adjacent to the city center, has a settlement area that occupies the border of the river flood canal. Gayamsari Subdistrict also has areas prone to flood, rob, and land subsidence (Ramadhany et al., 2012; Setyani & Saputra, 2016; Suripin et al., 2017.). This physical condition of the Gayamsari Sub-district settlement area is vulnerable to the development of ARI. In 2011, the number of ARI sufferers under five years old in Gayamsari Sub-District ranked second highest in the city of Semarang, which was 2982 cases. There is a positive relationship between housing and settlements condition with public health or the incidence of disease therein (Dewi, 2012; Priyono et al., 2013). So, the question is, "Is there a correlation between the settlement environmental quality and the incidence of ARI in Gayamsari Sub-District?" The main objective of this research is to find out the correlation between the settlement environmental quality and the ARI disease in Gayamsari sub-district, Semarang City. The research has used the quantitative descriptive method and spatial analysis using the Geographic Information System and Remote Sensing technology. The research area is Gayamsari Sub-district, Semarang City which has 7 villages with an area of 6.18 ha (Figure 1).

2. Data and Methods

Data used in this study are Quickbird imagery of Gayamsari Subdistrict in 2006 and 2016, as well as numbers of ARI incidence. Study of correlation between settlement environmental quality and ARI disease in Gayamsari Sub-district, used quantitative descriptive method, with spatial approach all data and information were analyzed quantitatively by utilizing High Resolution Satellite Imagery (CSRT) and Geographic Information System. Technique analysis used is overlay, scoring and statistics to determine the relationship between settlement environmental quality and the number of ARI events.

Stages of analysis performed are as follows: First, Analysis of the settlement environmental quality, aims to determine the condition of the settlement environmental quality in 2006, 2016, and changes between these 2 years. Parameters used are settlement density, building arrangement, road width, road conditions, green area/ vegetation, roof quality, settlement location, and flood potential. Each parameter used will have a range of values between 1, 2, and 3 and be given different weight based on its influence on settlement environmental quality and ARI disease. The weighting of each parameter can be seen in Table 1.

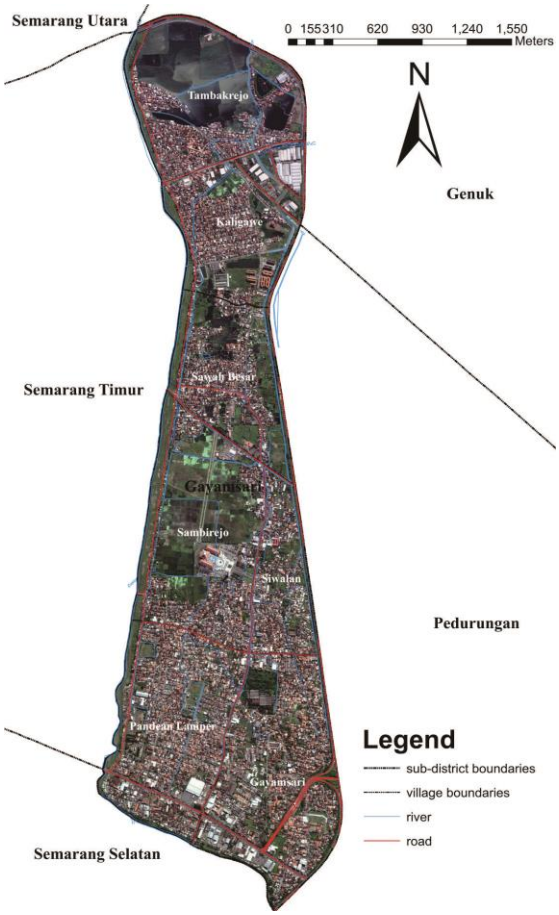

Figure 1. Research Location (analysis, 2019)

Table 1. Assessment of residential environmental quality parameters

Parameter	Weighting	Value					
		High, value = 1	Final score	moderate, value = 2	Final score	low, value = 3	Final score
Settlement density	3	Settlement density <40%	3	Settlement density 40-60%	6	Settlement density >60%	9
Buildings arrangement	1	≥ 50% buildings are arranged	1	25% - 50% buildings are arranged	2	>25% buildings are arranged	3
road width,	1	Road width > 6m,	1	Road width 4 – 6m	2	Road width <4 m	3
road conditions,	1	>50% road hardened		25-50% road hardened	2	<25% road hardened	3
green area/vegetation	2	> 50% green area/vegetation	2	25-50% green area/vegetation	4	<25% green area/vegetation	6
roof quality	2	Permanent (tile, concrete)	2	semi-permanent (asbestos, iron sheeting)	4	Non-permanent (bamboo, thatch, etc.)	6
settlement location,	3	distance from pollution sources ± 5km	3	distance from pollution sources ± 3km	6	distance from pollution sources ± 1km	9
flood area potential	2	distance from water resource >1 Km	2	distance from water resource 0,5-1 Km	4	distance from water resource <0,5 Km	6

Settlement environmental quality will be classified into 3 classes consisting of Class I for high quality, Class II for moderate quality, and Class III for low quality based on the sum of the values of each parameter that has been multiplied by weighting (Table 2). Settlement environmental quality change within a period of 10 years will be analyze using GIS by overlaying the results of each village classification in 2006 and 2016.

Table 2. Settlement environmental quality classification

No	Total final score range	class	classification
1	14-25	I	Good settlement environmental quality
2	26-35	II	moderate settlement environmental quality
3	36-45	III	Poor settlement environmental quality

Second, analysis of ARI events, aims to analyze the ARI diseases in Gayamsari District in 2006, 2016, and changes between these 2 years. ARI events are analyzed based on the incidence rate (IR). Incidence rate (IR) is the number of new cases of a disease that are found/reported at a time period compared to the number of people who might be affected by the disease in a particular location. The formula used to calculate the incidence rate is as follows:

$$Incident\ Rate\ (IR) = \frac{Number\ of\ new\ cases}{Number\ of\ people\ who\ might\ be\ affected\ by\ the\ disease} xConstants(100\%)$$

IR values in each village are classified into 3 classes consisting of Class I for low IR value, Class II for moderate IR value, and Class III for high IR value. Based on data obtained from Puskesmas Gayamsari Sub-district, the classification of ARI incidence rate values in Gayamsari Sub-district can be seen in Table 3. IR value change within a period of 10 years, will be analyze using GIS by overlaying the results of each village classification in 2006 and 2016.

Table 3. IR Classification

IR Value	Class	classification
5.05 - 6.60	I	Low IR value
6.61 - 8.16	II	Moderate IR value
8.17 - 9.71	III	High IR value

The last one is analysis of relation between settlement environmental quality and ARI events, aims to explain the relation between the settlement environmental quality and ARI events using correlation coefficient value of Spearman Rank correlation (Table 4). The data used is the percentage of low settlement environmental quality and ARI IR values in each village in 2006, 2016. Before it, data used have to be converted into ordinal data.

Table 4. Correlation coefficient (r) (Sukardi, 2003)

$-1 \leq r \geq 1$	
r=1	the relationship between variables X and Y is perfect and positive (close to 1, meaning that the relationship is very strong and in the same direction)
r=-1	-1, the relationship between variables X and Y is perfect and negative (close to -1, meaning that the relationship is very strong and in the opposite direction)
r=0	the relationship between variables X and Y is very weak or there is no relationship

3. Result and Discussion

3.1. Settlement Environmental Quality

Parameters used to analyze the settlement environmental quality are settlement density, building arrangement, road width, road condition, green area/vegetation, and the location of the settlement (Hidayah et al., 2018). This study uses the same parameters, and adding parameters of roof condition and flood potential, because the characteristics of the study are located in flood-prone areas. The settlement environmental quality in Gayamsari Sub-district in 2006 and 2016 has changed. In 2006, 5 villages (Pandean Lamper, Gayamsari, Sawah Besar, Kaligawe, Tambakrejo) had low quality (class III), and 2 villages (Sambirejo, Siwalan) had moderate quality (class II). Meanwhile In 2016, all villages had low quality (class III). Table 5 shows the result of settlement environmental quality score in Gayamsari Sub-District.

Table 5. Settlement environmental quality score

No	villages	A		B		C		D		E		F		G		H		I		J	
		1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	1
1	Pandean Lamper	9	9	1	1	3	3	1	1	6	6	2	2	9	9	6	6	37	37	III (low)	III (low)
2	Gayamsari	9	9	2	3	3	3	1	1	4	6	2	2	9	9	6	6	36	39	III (low)	III (low)
3	Siwalan	9	9	3	3	3	3	2	2	2	6	2	2	9	9	2	2	32	36	II (moderate)	III (low)
4	Sambirejo	9	9	3	3	3	3	1	1	4	6	2	2	9	9	4	4	35	37	II (moderate)	III (low)
5	Sawah Besar	9	9	3	2	3	3	1	1	6	6	2	2	9	9	6	6	39	38	III (low)	III (low)
6	Kaligawe	9	9	2	2	3	3	1	1	6	6	2	2	9	9	6	6	38	38	III (low)	III (low)
7	Tambakrejo	9	9	3	3	3	3	1	1	6	6	2	2	9	9	6	6	39	39	III (low)	III (low)

Description:
A = settlement density
B = buildings arrangement
C = road width
D = road condition
E = green area/vegetation
F = roof quality
G = settlement location
H =flood area potential
I = total final score
J = settlement environmental quality
1= 2006
2 = 2016

Result showed that decline of settlement environmental quality in study area are caused by the change of building arrangement and green area/vegetation. The Same research showed that the decline in settlement environmental quality caused by an increase in settlement density, a decrease in vegetation area and a decrease in infrastructure (Ayuningtyas & Pigawati, 2018; Pigawati et al., 2019). Infrastructure parameter is not used to analyze the settlement environmental quality in study area because the condition of infrastructure in the city center tends to be the same so it does not affect the results. The distribution of the settlement environmental quality change can be seen in Figure 2.

3.2. ARI incidence

In 2006, number of ARI incidence in Gayamsari Sub-district were 4798 cases. Whereas in 2016, the number of ARI incidence were 5667 cases (Puskesmas Kecamatan Gayamsari, 2016). This shows an increase in the past 10 years of 649 cases. In 2006, 2 villages (Pandean Lamper, Gayamsari) had low IR value (class I), 3 villages (Sawah Besar, Kaligawe, Tambakrejo) had moderate IR value (class II), and 2 villages (Siwalan, Sambirejo) had High IR value (class III). In 2016, 1 village (Gayamsari) had a low IR value (class I), 5 villages (Pandean lamper, Siwalan, Sawah Besar, Kaligawe, Tambakrejo) had moderate IR value (class II), and 1 village (Sambirejo) had High IR value (class III). Based on its classification, 2 villages, (Kaligawe and Tambakrejo), experienced a change from high IR value (class III) to moderate IR value (class II). Table 6 shows the results of the assessment of ARI incidence in Gayamsari District in 2006 and 2016. Distribution ARI IR value changes seen in Figure 3.

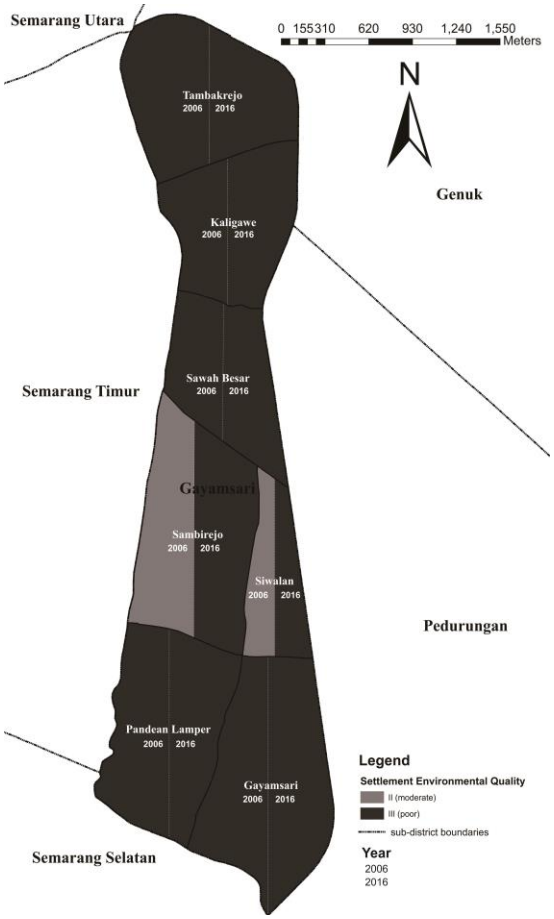

Figure 2. Settlement environmental quality change

Table 6. Assessment of ARI Incidence

No	Villages	ARI incidence							
		2006				2016			
		Population	Number of sufferer	Incidence Rate	Classification	Population	Number of sufferer	ARI Incidence Rate	Classification
1	Pandean Lamper	16579	1107	6.68%	II (moderate)	14988	1053	7.03%	II (moderate)
2	Gayamsari	13242	669	5.05%	I (low)	13355	778	5.83%	I (low)
3	Siwalan	5580	417	7.47%	II (moderate)	6875	499	7.26%	II (moderate)
4	Sambirejo	5913	564	9.54%	III (high)	8654	840	9.71%	III (high)
5	Sawah Besar	7872	619	7.86%	II (moderate)	9798	729	7.44%	II (moderate)
6	Kaligawe	8828	726	8.22%	III (high)	10308	772	7.49%	II (moderate)
7	Tambakrejo	8696	722	8.30%	III (high)	10209	802	7.86%	II (moderate)
	Total	66710	4798	0.0719	6.68%	74187	5667	7.63	7.03%

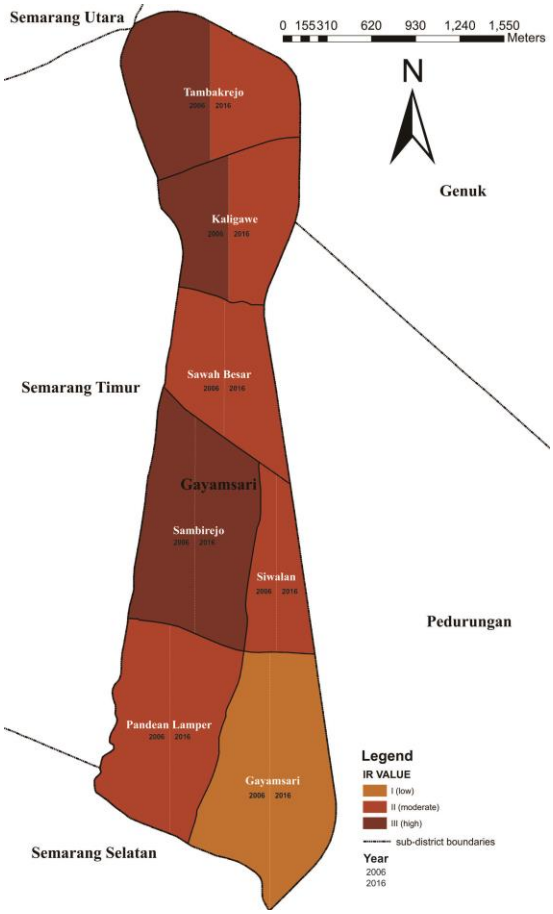

Figure 3. IR Value change

3.3. Correlation of settlement environmental quality and ARI disease

Table 7 shows the comparison of low settlement environmental quality and the incidence of ARI incidence in 2006 and 2016. The similarity of classes in the settlement environmental quality and the incidence of ARI can indicate a relationship. This happened in Gayamsari village in 2006 and can also be seen in Sawah Besar, Kaligawe, and Tambakrejo in 2006, as well as in Pandean Lamper, Gayamsari, Sambirejo, Sawah Besar, Kaligawe and Tambakrejo village in 2016.

Table 7. Comparison of low settlement environmental quality and ARI IR value

No	Village	Percentage of low settlement environmental quality				ARI IR value			
		2006		2016		2006		2016	
		Area (%)	Class	Area (%)	Class	IR	Class	IR	Class
1	Pandean Lamper	51.49	1	69.31	2	6.68	2	7.03	2
2	Gayamsari	40.57	1	48.11	1	5.05	1	5.83	1
3	Siwalan	0	1	48.78	1	7.47	2	7.26	2
4	Sambirejo	52.78	2	86.11	3	9.54	3	9.71	3
5	Sawah Besar	53.85	2	66.67	2	7.86	2	7.44	2
6	Kaligawe	72.73	3	72.73	2	8.22	3	7.49	2
7	Tambakrejo	71.79	3	71.79	2	8.3	3	7.86	2

Comparison of low settlement environmental quality and ARI IR valu can be seein in Figure 4. Forthemore, Table 8 and Table 9 show the results of the correlation analysis between settlement environmental quality and the incidence of ARI in 2006 and 2016. In 2006, the settlement environment quality and ARI disease had a very strong and positive correlation (r = 0.870). Same result also seen in 2016, where the settlement environment quality and the incidence of ARI had a very strong and positive correlation (r = 839). The same research shows that the settlement environmental quality has a positive relationship to public health as seen based on the number of patients with DHF, diarrhea and tuberculosis (Priyono et al., 2013; Yuniawan, 2011). This study uses ARI disease because ARI is recorded as the disease with the highest number of sufferers in the study area (Semarang City Health Service, 2015).

Figure 4. Comparison of low settlement environmental quality and ARI IR value

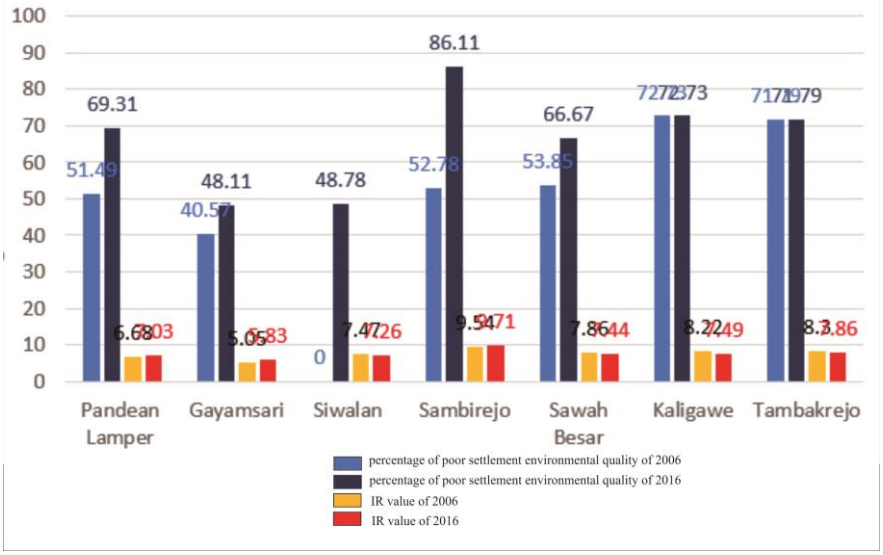

Table 8. Correlation of settlement environmental quality and ARI disease in 2006

			Settlement environmental quality	ARI disease
Spearman's rho	**Settlement environmental quality**	**Correlation Coefficient**	1.000	.870*
		Sig. (2-tailed)	.	.011
		N	7	7
	ARI disease	**Correlation Coefficient**	.870*	1.000
		Sig. (2-tailed)	.011	.
		N	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

Table 9. Correlation of settlement environmental quality and ARI disease in 2016

			Settlement environmental quality	ARI disease
Spearman's rho	**Settlement environmental quality**	**Correlation Coefficient**	1.000	.839*
		Sig. (2-tailed)	.	.018
		N	7	7
	ARI disease	**Correlation Coefficient**	.839*	1.000
		Sig. (2-tailed)	.018	.
		N	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

4. Conclusion

The settlement environmental quality and ARI in the study area has changed over the past 10 years. The most significant changes in the settlement environmental quality were seen in the Siwalan and Sambirejo villages, and were caused by buildings arrangement and green area/vegetation. Meanwhile, the most significant change in ARI IR values was seen in the Kaligawe and Tambakrejo villages. There is a very strong and positive correlation between settlement environmental quality and ARI disease in 2006 and 2016. These results are consistent with the results of research by (Dewi, 2012; Gan et al., 2017; Lévesque et al., 2018; Priyono et al., 2013) that the settlement environmental quality has a relationship with public health or incidence of disease. The lower the quality of settlements will be in line with poor health conditions. The health condition of a community can be influenced by settlement environmental quality, and other factors such as climate, health services, behavior, habits and culture of healthy living.

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