The quality of soil and high prevalence of hookworm infection in Muara Kaman and Marangkayu districts, Indonesia

Blego Sedionoto[1,2*],Sueptrakool Wasessombat[1], Chuchard Punsawad[3], WitthayaAnamnart[4]

[1]School of Allied Health Sciences, Walailak University
[2]Faculty of Public Health, Mulawarman University
[3]School of Medicine, Walailak University
[4]School of Public Health, Walailak University

***Corresponding author:**
BlegoSedionoto
School of Allied Health Sciences, Walailak University 222 Thaiburi,
Thasala District, Nokhonsithammarat 8061, Thailand
Phone numbers: +62-81350016616, +66-756727034
E-mail address: blego.sedionoto@gmail.com

Abstract

Background: Hookworm infections spread in developing countries especially rural areas which have environmental risk factors include physical and chemical factors of the soil that potentially facilitate the transmission of hookworm infection. **Aims:**The study identified the infection prevalence and correlation of hookworm infection with soil quality. **Settings and Design:** This was a cross-sectional study involving 213 participants from rural areas in Muara Kaman and Marangkayu districts, East Kalimantan province, Indonesia. accomplished a cross-sectional study amid 213 participants from rural areas in Muara Kaman and Marangkayu districts, East Kalimantan province, Indonesia. **Methods and Material:** Hookworm infections were diagnosed by Kato Katz and Koga agar plate culture. **Statistical analysis used:** This study also performed a Pearson chi-square test and odds square and odds analysis. **Results:**Among 213 participants hookworm infection occurred to 61.1% and 37.6% respectively, wiyh an overall prevalence of 43.7%. The quality of soil, such as organic carbon, pH, and clay content, soil texture, elevation, vegetation and village area were significantly correlated with hookworm infection (p= 0.000) and the odds of hookworm infection with OR of > 1. While dry or wet soil was not significantly with hookworm infection. **Conclusions:**Organic carbon content in soil had an indirect effect of hookworm for supporting survival. Lower elevation and buffer of the river had a potential risk factor of hookworm infection by increasing fecal contamination of soil surrounding the

areas. Soil that covered by palm and rubber plantation is more potential to get infected by hookworm infection than rice field.

Keywords:quality of soil, hookworm infection, rural areas, Indonesia

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Introduction

The prevalence of hookworm infection is of a global serious public health concern globally. Hookworm infection and strongyloidiasis are prevalent in a poor rural communities in tropical and subtropical areas in many developing countries [6]. They are transmitted through soil as an endemic in tropical and temperate regions. The prevalence of 439 million hookworm infections was reported in 2010 that 439 million [9, 19, 12].

Humans acquire the hookworm infection through direct skin contact with infective larvae in the third-stage where the soil is contaminated by human feces penetrating intact human skin and eventually reach the small intestine [1].

Generally, hookworm infection occur to poor people with poor environmental sanitation and warm and humid environment [16].Environmental factors especially the quality of soil have contributed to its transmission, growth and development [10; 8]. Characteristics of soil supported the survival of hookworm in the environment, for example, sandy loam soil with organic material content can facilitate to develop larvae of hookworm in each stage [2]. Geographical characteristics of soil also affect the growth of hookworm and the probability of hookworm contamination in the soil around elevation, vegetation and village areas, according [6], high prevalence of hookworm infection in Timor Leste (62%) [6].

Elevation of soil may effect to increase of the risk of hookworm infection. Sources of contaminants come from by fecal animal and human from high elevation to lower elevation, in East Kalimantan province the higher elevation of ≥46m usually involves forest areas and rubber or palm plantation. When communities defecated in rubber or palm plantation, the hookworm infection could be transmitted to the village or rice fields. A previous study has found rural areas dominated by agriculture areas had common cases of hookworm infection [11]. In some areas in East Kalimantan, the soil under palm and rubber plantation had warm temperatures and wet texture with organic material. The study explained the determinants of environmental risk factors especially especially of soil. Filaria hookworm contamination can infect humans through skin penetration. To avoid that rice plantation has to be irrigated during farming activity so that larva of hookworm do not penetrate to skin.

Subjects and Methods

Ethical consideration

An official permission and ethical clearance for the collection human fecal samples were app by the headmaster and teachers. The study protocol was approved by the Ethical Clearance Committee on human rights related to research involving human subjects, Walailak University HE: No.WUEc-18-034-01.

Study Setting and Population

The community-based study was carried out in the rural areas of Muara Kaman district and Marangkayu district East Kalimantan province Indonesia. This research is a community based, was conducted from July 2018 to September 2019 and involved 213 participants who sent stool samples during the data collection.

Field Procedures

This study collected stool samples at three stages. On the first day, the researcher asked for family heads, and members permission to request stool samples. On second day, the researcher collected stool samples, and examined them in the biomedical laboratory, Faculty of Public Health Mulawarman University for diagnosis. On the last day, the environmental condition around houses were observed and soil were collected.

Laboratory Procedures

Agar plate culture and Kato Katz technique

Agar plate culture was done in this study. It followed the concept of Koga et al, showing a few grams of stool were placed at the center of nutrient agar and kept at room temperature for five days. Tracks made by larva crawling and larvae or adult worms were observed. If positive, 10 ml of 10% formalin was added to the agar surface for 5-10 minutes and transferred to a centrifuged tube. Centrifugation occurred at 2,500 rpm for 5 minutes and supernatant was discarded. The sediment would be examined for hookworm larvae or adult worm [17,15].

For Kato-Katz thick smear, 50 mg of stool was placed on a slide and covered with a cellophane paper soaked in glycerin solution for 24 hours. The stool was spread out using a rubber stick. After 30 minutes, it was examined and counted for eggs growing at the moment [4].

Risk Factors Data

Demographic data were collected through questionnaire, while the quality of soil observed from the organic carbon, clay, and pH content was diagnosed by the soil laboratory at Mulawarman

University. Vegetation, elevation, village area, and types of soil around houses were reported in an observation form.

Data Analysis

The prevalence of hookworminfection was stratified according to demographic data, sanitation facilities and personal hygiene, and environmental data, and then reported by the descriptive statistic. Statistical analysis was performed using a Chi-square test in SPSS verse 22. The chi-square analysis aimed to evaluate the correlation of hookworm infection with the quality of soil. The p-value was<0.05. Furthermore the analysis of risk was estimated by odds ratio Chi-Square with aconfidence interval of 95%.

Results

Study Sample

A total of 213 individuals who participated in this study were mostly 2 and 70 years. They came from 28 villages, with detail 12 villages from Muara Kaman district and 16 villages from Marangkayu district, East Kalimantan province Indonesia.

Among 28 villages, there were10-15 households with 2 to 3 participants in each household.This participants from Muara Kaman district and Marangkayu district were 95 (44.6%) and 118 (55.4%) respectively. There were 130 males participants (61%) which were dominant than female 83(39%) from overall samples. The number of participants in the 2-12 age group was 114 (53.5%). While that of participants in the 3-above age groups was 93 (46.5%). Some participants worked as farmers (32.9%), while some worked at home (25.8%). Others worked at school(38.0%), andthe rest worked at other sector (3.3%) (see Table 1):

Table1 Characteristics of Participants

Variable	Category	N (%)
District	Muara Kaman	95(44.6)
	Marangkayu	118(55.4)
Gender	Male	130(61.0)
	Female	83(39.0)
Age (years)	2-12	114(53.5)
	13 and above	93(46.5)
Types of Employment	Farmer	70(32.9)
	At home	55(25.8)
	At school	81(38.0)
	Others	7(3.3)

This study also explored the correlation of environmental factors with the quality of soil, including clay content, texture of the soil, village area, vegetation covering the soil, the elevation above the sea surface, and soil humidity as described in Table 2.

Table 2. Quality of soil and distribution of Participants

Variable	Category	N (%)
Organic carbon content in soil	<2.47%	91(42.7)
	2.47-4.04%	122(57.3)
pH of the soil	<5.85	102(47.9)
	5.85-6.92	111(52.1)
Clay content in the soil	<18.5%	96(45.1)
	18.5-42.50%	117(54.9)
Elevation of soil from above of the sea	<41.6m	97(45.5)
	41.6-50m	116(54.5)
Texture of the soil	Sandy soil with organic material	139(65.3)
	Non-sandy soil with organic material	74(37.3)
Vegetation that covering the soil	Surrounding palm plantation and/or rubber plantation	167(78.4)
	Surrounding rice field	46(21.6)
Village areas of soil	Buffer along the river or sea	166(77.9)
	Hills	47(22.1)
Soil humidity	Dry soil	169(79.3)
	Wet soil	44(20.7)

The member of participants in the levels of organic carbon content of<2.47% and 2.47-4.04% were 91(42.7%) and 122(57.3%) respectively. In pH levels of < 5.85 and 5.85-6.92 there were 102(47.9%) and 111(52.1%) participants. As many as 45.1% of the participants were categorized into clay contentof<18.5% and 54.9% of them were at clay 18.5-42.50%. In the elevation of< 41.6m thre were 45.5% of the participants reported. While 54.9% were categorized into elevation 41.6-50m. As many as 65.3% of participants houses were surrounded by sandy soil with organic material. Most of the participants (77.9%) lived near buffer the river. Most of them (79.3%) lived in areas which the soil was dry.

Parasitological Findings

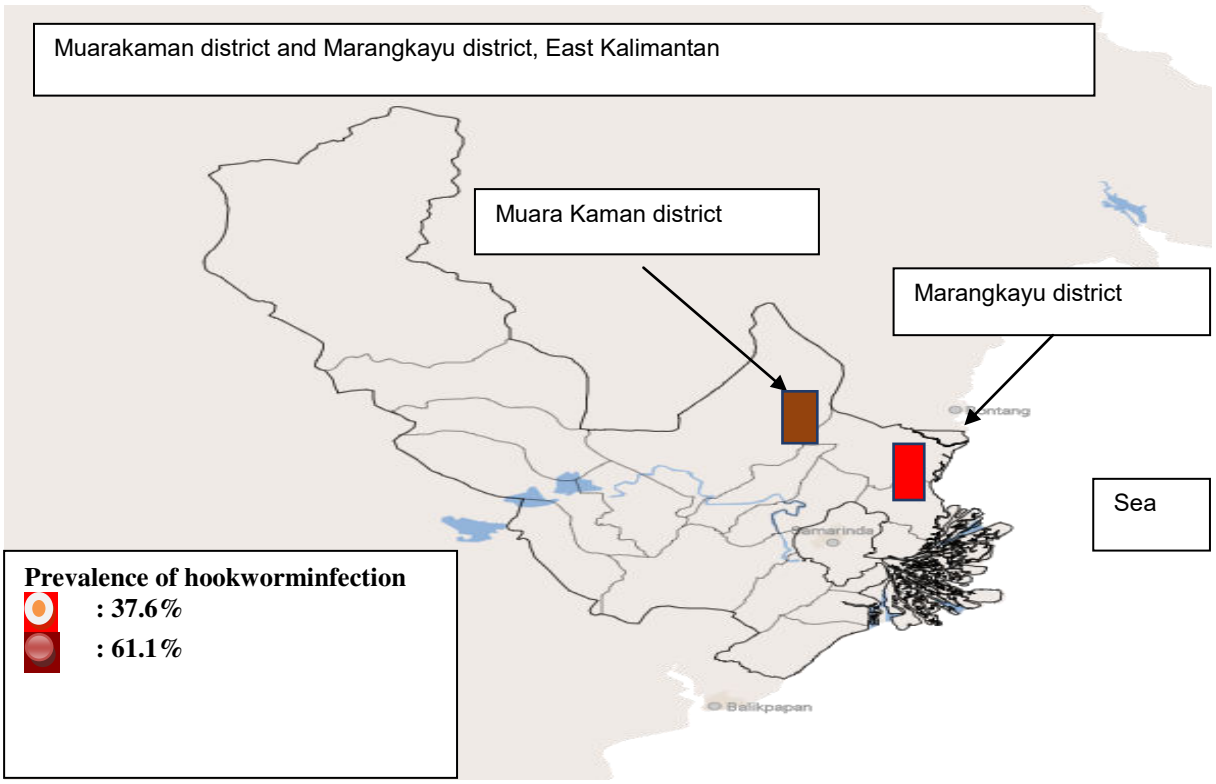
The prevalence hookworm infection was diagnosed using Kato Katz technique and Agar Plate Culture method analysing 213 tested samples from Muara Kaman district and Marangkayu district:

Table 3. Prevalence of hookworm infection among communities in East Kalimantan province

Infections	Muara Kaman district		Marangkayu district		Total	
	Positive	Negative	Positive	Negative	Positive	Negative
Hookworm infections	58 (61.1%)	37 (38.9%)	35(37.6%)	83(70.3%)	93 (43.7%)	120 (56.3%)

The prevalence of hookworm infection in East Kalimantan with positive and negative cases, 98 (43.7%), and 120 (56.3%) respectively, while the prevalence of hookworm infection Muara Kaman district 58 (61.1%) is higher than Marangkayu district 35 (37.6%).

Figure 1. Prevalence of hookworm infections in Muara Kaman district and Marangkayu district, East Kalimantan province



Soil and prevalence of hookworm infectionin East Kalimantan

The correlation analysis of quality of soil with the prevalence of hookworm infections in East Kalimantan province, Indonesia is explained in Table 4.

Table 4. Soil and prevalence of hookworm

Variable	Category	Hookworm infection		*P-value*
		Negative n (%)	Positive n (%)	
Organic carbon content in the soil	<2.47%	57(62.6)	24(37.4)	0.000
	2.47-4.04%	63(51.6)	59(48.4)	
pH of the soil	<5.85	62(60.8)	40(39.2)	0.076
	5.85-6.92	58(52.3)	53(47.7)	
Clay content in the soil	<18.5	57(54.2)	44(45.8)	0.413
	18.5-42.50	68(58.1)	49(41.9)	
Elevation of the soil	<41.6m	38(39.2)	59(60.8)	0.000
	41.6-50m	82(70.7)	34(29.3)	
Texture of the soil	Sandy soil with organic materials	77(55.4)	62(44.6)	0.591
	Non-sandy soil with organic material	43(58.1)	31(41.9)	
Vegetation covering the soil	Surrounding palm plantation and/or rubber plantation	85(50.9)	82(49.1)	0.000
	Surrounding rice field	35(76.1)	11(23.9)	
Village areasl	Buffer along the river or sea	84(50.6)	82(49.4)	0.000
	Hills area	36(76.6)	11(23.4)	
Soil humidity	Dry soil	99(58.0)	71(42.0)	0.178
	Wet soil	22(50.0)	22(50.0)	

The results statistical analysis between the quality of soil (organic carbon content in the soil, vegetation, and village areas) and hookworm infection show a significant correlation ($p<0.05$). While the pH of the soil, clay content in the soil, texture of the soil, were not significantly correlated with the prevalence of hookworm infection in East Kalimantan province.

Environmental risk factors which had higher association/correlation with hookworm infection include organic carbon content in the soil, elevation, vegetation, and village areas with a p-value of 0.000,

The odd ratio of hookworm infection by the quality of the soil is presented in Table 5.

Table 5.Analysis of the odds ratio between soil quality and hookworm infection

Essential risk factors	Category	Hookworm infection		OR(95%CI)
		Negative n(%)	Positive n(%)	
Organic carbon content in the soil	<2.47%	57(62.6)	24(37.4)	0.83 (0.70-0.97)
	2.47-4.04%	63(51.6)	59(48.4)	1.30 (1.03-1.64)
Elevation of the soil	<41.6m	38(39.2)	59(60.8)	1.87 (1.52-2.30)
	41.6-50m	82(70.7)	34(29.3)	0.50 (0.40-0.62)
Vegetation covering the soil	Surrounding palm plantation and/or rubber plantation	85(50.9)	82(49.1)	2.47 (1.59-3.83)
	Surrounding rice fields	35(76.1)	11(23.9)	0.80 (0.83-0.88)
Village areas	Buffer river/sea	84(50.6)	82(49.4)	2.54 (1.64-3.93)
	Hill area	36(76.6)	11(23.4)	0.79 (0.72-0.87)

Organic carbon content in soil in the category of 2.47-4.04% was higher OR (OR: 1.30 (95%CI: 1.03-1.64) than in category of <2.47% (OR: 0.83 (95%CI:0.70-0.97). Elevation at < 41.6m has higher OR (OR: 1.87: 95%CI:1.52-2.30) than at 41.6-50 m (OR: 0.50 (95%CI: 0.40-0.62) and vegetation surrounded by palm plantation and/or rubber plantation and /or rubber plantation had a greater OR (OR: 2.47: 95%CI:1.59-3.83) than rice fields(OR: 0.80 (95%CI:0.83-0.88). Village areasnear buffer along the river or sea had a higher OR(OR:2.54: 95%CI: 1.64-3.93) than hill areas(OR: 0.79: 95%CI: 0.72-0.87).

Discussion

Quality of soil was affected by organic carbon content and other environment factors such as vegetation, elevation, and village areas All of these factors had a significant correlation with hookworm infection ($p<0.05$). While the pH of the soil, clay content in soil and texture did not have a significant correlation with hookworm infection. The determinant risk factor was shown by the odd ratio of hookworm infection at more than 1 (OR>1, 95%CI),

The significant correlation of carbon content in soil with hookworm infection obtained a p-value of 0.000, while the odd of hookworm infection had high in carbon content at ≥2.47% (in group 2.47-4.04%). The prevalence of hookworm infection in the group was (48.4%), which was higher than

organic carbon content < 2.47% category (37.4%). A previous study in Cambodia explains that a high amount of soil organic carbon content had notaffected to the prevalence of hookworm infection but would affect the prevalence of *S. stercoralis* [13],It is similar to a study in East Kalimantan which find more abundance of organic carbon soil did not affect to reduce hookworm infection. However, Sebastian H, at al (2018) point out organic carbon content in soil had an indirect effect for nematode , especially on the abundance, cell size, and activity of bacteria (Escherichia coli) [5]. Adsorption of organic carbon on bacterial cells, serving as food for the nematodes, may have been an important factor for the availability of organic carbon for hookworm.

Elevation of soil from the above the sea was significantly correlated with hookworm infection (p= 0.000). Participants who lived in the elevation of <46m above sea (60.8%) got infected by hookworm more than in the lower elevation. The odd ratio of hookworm infection by elevation of soil was 1.87 (95%CI: 1.52-2.30). Similar to study at western Côte d'Ivoire find that hookworm infection was significantly associated with elevation [3]. Lower elevation may effect to increase of potential risk hookworm infection. The sources of contaminant were from animal and humanfeces remaining from high elevation to lower elevation. In EastKalimantan province the higher elevation ≥46m is forest areas and rubber or palm plantation. When people defecated in rubber or palm plantation on higher elevation, the waste can contaminate the village or rice fields. In rainy season, water running from plantation or forest to the village or rice fields may bring the eggs or larvae.This potential infection the houses.

The prevalence of hookworm infection on the soil covered by palm or rubber plantation (49.1%) was larger than rice fields (23.9%) respectively. Potential risk of hookworm infection on soil surrounded by palm and rubber plantationOR: 2.47: 95%CI: 1.59-3.83) more than by rice fields(OR: 0.80 (95%CI: 0.83-0.88). Generally, soil under palm and rubber plantation was warm some of wet areas. If filarial hookworm contaminates the areas it can affect human through skin penetration. However, soil covered by palm plantation has more potentially of hookworm contamination than rice fields. Rice field can have irrigation during farming activity, and it will avoid the hookworm grow despite some potential contamination caused by hookworm and *S. stercoralis* [14].

The buffer along the river or sea had a higher prevalence of hookworm infection (49.4%) than hill area (23.4%). Village area was significantly correlated with hookworm infection (p=0.000). Buffer along river or sea had the highest odds ratio of hookworm infection (OR: 2.54: 95%CI: 1.64-3.93) compared to other variables. Muara Kaman district is surrounded by palm plantation and rivers, and thus it has greater possibility of hookworm infection. A similar study in Manufahi district, Timor Lestefind the prevalence of hookworm infection in rural areas was (62%) [6]. The buffer along the river is an area near river at 100-200 m distance. Flooding some time occurs in village near buffer and they can be contaminated because of defecation in the river. During heavy rain contaminants could runoff

from forest and palm or rubber plantation to villages. Group with greater risk of infection were children and women as they spent more time around the houses.

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