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THE IMPACT OF EARTHWORM BIOPORE HOLES ON GROUNDWATER ABSORPTION

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Abstrak. which is in nature both ossifying and closing ground surface, causes the decline of ground water infiltration. Some efforts to enlarge ground water infiltration have already been done, for example, by making infiltration wells and bioporic infiltration holes. Earthworms naturally do some activities which contribute to make ground water infiltrate. Due to this fact, a research needs conducting on bioporic infiltration holes of earthworms. This research was performed in Sukoharjo, Surakarta from September 2007 up to July 2008. The study aimed to search the diameter and amount of width units of bioporic infiltration holes of earthworms. The number of infiltration holes of earthworms was counted on the basis of measurement plots of 50 cm x 50 cm. The plots, 20 in number, were placed on a piece of land randomly. Each hole of earthworms (biopore) in every plot was measured to find its diameter. The result of the research showed that the average diameter of bioporic infiltration holes of earthworms was 4,58 mm, and there were 20 holes found in every square meter of land. The bioporic infiltration holes of earthworm could extend the infiltration area of ground water as many as 873 times

Keywords: earthworms; bioporic; ground water; biopore

I. INTRODUCTION

Development will have an impact on environmental changes, one of which is reduced groundwater absorption. This occurs due to the hardening of the land surface, for example the presence of houses and asphalting of the yard. This condition has an impact on reducing the porosity of the soil to water. A more severe impact is the reduction of groundwater and flooding can occur. Efforts have been made to create water absorption in the form of infiltration wells, but they have not been effectively implemented and still need to be socialized. The Jakarta area is an example of the impact of development on the existence of groundwater. Efforts in the field of Law are carried out by issuing regulations made by the DKI Jakarta Provincial Government. In the Regulation of the Governor of the Special Capital Region of Jakarta Province No.: 68 of 2005, chapter V, article 4, concerning the Obligation to Make Infiltration Wells, namely the obligation to make infiltration wells for individuals and legal entities is addressed to a. every person responsible for a building that covers the land surface; b. every applicant from a deep well user; c. every owner of a building with a pile construction and/or utilizing deep groundwater of more than 40 m; and d. every industrial business that utilizes surface groundwater **[1][2].** Brata and Nelistya **[3]** provide a very simple solution, namely by making water absorption holes known as Biopore Infiltration Holes (LRB). The benefits of biopore infiltration holes in overcoming the above problems are: improving soil ecosystems, absorbing water, preventing flooding; increasing groundwater reserves, overcoming drought, and overcoming waterlogging problems. Biopores are spaces or pores in the soil formed by living things, such as soil fauna and plant roots. The shape of biopores resembles a burrow (small tunnel) and branches which are very effective in channeling water and air to and in the soil (Brata and Nelistya, **[3]**).

Earthworms are generally known as animals that play a role in composting (Rukmana **[4]**). However, earthworms also naturally play a role in making biopores. Worms that often make biopores/holes in the soil are earthworms that are grouped into anesic and endogeic worms (NRRI **[5]**). Earthworm biopores can help the process of groundwater absorption (Bohlen **[6]**; Flury and Fluhler **[7]**; Hardin **[8]**). Anesic earthworms make biopore holes that tend to be vertical and deep, while endogeic worms make biopore holes that tend to be horizontal and branched (NRRI **[5]**). Research needs to be conducted on the size of the diameter of earthworm biopores and the number of earthworm biopores per unit area of land. This is related to the ability of earthworms to help expand the surface of groundwater absorption. It is expected that the more biopores there are in a location, the better the location will be in helping groundwater absorption. In addition, the existence of worm biopores that are carried out naturally without any hassle and human engineering, does not require costs and other resources. Biopores made by human engineering, LRB, have a diameter of 10-30 cm (Brata and Nelistya **[3]**), while the natural biopores made by earthworms

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are not yet widely known in size. This study aims to determine the diameter of earthworm biopore holes and the number of holes per unit area of land, so that the ability of earthworms to help expand the surface of groundwater absorption can be predicted. Human development has a significant impact on the environment. Changes in the hydrological cycle are one of the worrying impacts, especially the balance of water in the soil is disturbed, in the form of reduced water in the soil. Water absorption into the soil is reduced, due to soil compaction by the use of heavy equipment during forest clearing, opening of the topsoil to the effects of prolonged rain, excessive grazing, and inappropriate agricultural practices. In addition, the increase in the area of land that does not absorb water, such as that used for roads, industrial areas, residential areas and rural areas is the cause (Whitten et al. **[9]**).

The city of Jakarta is one place that has felt the importance of maintaining the existence of groundwater. The groundwater awareness movement program launched by the DKI Jakarta Provincial Government offers the 5R concept, namely reduce (save), reuse (reuse), recycle (reprocess), recharge (refill), and recovery (re-function). Recharging groundwater is done by making infiltration wells and Biopore Infiltration Holes (Antara **[10]**).

Biopore Infiltration Holes (LRB)

Biopore infiltration holes (LRB) are cylindrical holes with a diameter of about 10 cm dug in the ground. Its depth does not exceed the groundwater level, which is about 100 cm from the ground surface. LRB can increase the soil's ability to absorb water. The water is absorbed through the biopores that penetrate the surface of the LRB walls into the soil around the hole. This will increase the water reserves in the soil and prevent water flow on the ground surface (Brata and Nelistya **[3]**).

Figure 1. Principle of Biopore Infiltration Holes (LRB) resulting from human engineering (TBI **[11]**).

Biopore infiltration holes (LRB) are developed based on ecohydrological principles, namely by improving the condition of the soil ecosystem will improve the hydrological function of the ecosystem. The use of organic waste into small and deep holes can actually create a good habitat for various soil organisms. Soil organisms can accelerate the weathering of organic materials and increase the formation of biopores that can facilitate water absorption and the exchange of O2 and CO2 in the soil (Brata and Nelistya**[3]**). The benefits of biopore infiltration holes (LRB) are: 1) improving the soil ecosystem; 2) absorbing water, preventing flooding; 3) increasing groundwater reserves; 4) overcoming drought; 5) facilitating waste management and maintaining cleanliness; 6) converting waste into compost; 7) reducing greenhouse gas emissions and methane; and 8) overcoming problems caused by puddles (Brata and Nelistya **[3]**). Water absorption into the soil can be facilitated by the presence of biopores that can be created by soil fauna and plant roots (Brata and Nelistya **[3]**). Earthworms are soil fauna that play a very important role in improving soil conditions. This fauna can carry out soil porosity by creating biopores. Earthworm biopores can help the groundwater absorption process (Bohlen **[6]**; Flury and Fluhler **[7]**; Hardin **[8]**; Hanafiah, et al. **[12]**).

Earthworm Biopores

Biopores are spaces or pores in the soil formed by living things, such as soil fauna and plant roots. The shape of biopores resembles a hole (small tunnel) and branches that are very effective in channeling water and air to and in the soil. Holes in biopores are formed by the growth and development of plant roots in the soil and the increasing activity of soil fauna, such as worms. The number and size of biopores will continue to increase following the growth of plant roots and the increase in the population and activity of soil organisms (Brata and Nelistya **[3]**; Hanafiah et al. **[12]**). The existence of earthworm biopores can be seen by the characteristics of worm droppings around the hole (Murie **[13]**). Based on their role in the ecosystem, earthworms can be grouped into epigeic, anesic, and endogeic groups: (Handayanto and Hairah **[14]**; NRRI **[5]**): Epigeic is a group of worms that live and feed on the soil surface, play a role in destroying litter and releasing nutrients but are not active in spreading litter into the soil profile. Earthworms included in this group are small: 1-7 cm and have color pigments. This type is called litter transformers or litter destroyers, because they play a role in in-situ decomposition through fragmentation and physically crushing litter. Examples are Amynthas gracilis. Dendrobaena octaedra, and Lumbricus rubellus.

Anecic is a group of earthworms that move litter from the soil surface and actively eat and move into the soil to protect themselves from predators or unfavorable climate conditions. This group is a type of pigmented earthworm, some of which have more pronounced dorsal pigments. Large worms with a length of 8-15 cm. The main effect of this anecic is to move litter from the litter layer and take it to a different place or environment, for example the lower soil layer. This condition dramatically changes the kinetics of decomposition and the spatial distribution of its products. This type of worm is called ecosystem engineering or a group of diggers. Its ability to dig soil can reach a depth of 2 meters from the soil surface. The shape of biopores is generally vertical without branches. This type of earthworm will affect the physical properties of the soil, including structure and hydraulic conductivity. An example is Lumbricus terrestris.

Endogeic is a group of earthworms that live in the upper soil, are eaters of organic matter and dead plant roots and clay (Geophagus). These worms are also called ecosystem engineers, making horizontal and branched tunnels.

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Earthworms that are classified as this type develop and interact with soil microorganisms to release enzymes that are useful in the decomposition of low-quality organic matter. In general, worms do not have color pigments, measuring 2-12 cm. Some species can destroy soil organic matter, especially light fractions because earthworms are able to produce certain enzymes. For example, Apporectodea trapezoids.

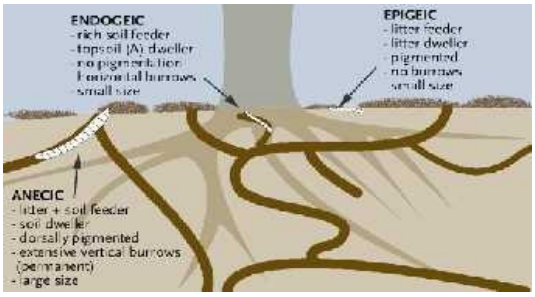

Figure 2. Description of worm groups based on their ecosystem: epigeic, anesic, and endogeic (Source: NRRI, **[5]**)

The grouping of worms based on their characteristics above clearly shows that worms have the ability to create natural biopore infiltration holes.

II. RESEARCH METHODS

The study was conducted in September 2007 – July 2008, in Sukoharjo, Surakarta. Materials and tools used: ruler, rectangular plot wire (50 cm x 50 cm), stationery. Method: the calculation of the number of holes was done by placing a rectangular plot wire (50 cm x 50 cm) on the sampling site. The number of earthworm biopore holes found was recorded. The calculation results were recorded as data on the number of holes per unit area of land. Each earthworm biopore hole was measured for its diameter using a ruler. The measurement results were recorded as data on the diameter of the earthworm biopore hole **[1]**. This method was carried out for up to 20 plots. The plot selection was done randomly.

III. RESULTS AND DISCUSSION

The results of the study on calculating the number of earthworm biopore infiltration holes and the results of measuring their diameter can be seen in Table 1. The average number of holes per 2,500 square centimeters (50 cm x 50 cm) is 5 holes, while the average hole diameter is 4.58 mm or 0.458 cm. The concept of man-made biopore infiltration holes is the creation of holes for water infiltration and activating soil biological processes related to the decomposition of organic matter by microorganisms. This continues to form soil porosity on the walls of the infiltration hole, while the concept of earthworm biopore infiltration holes is a natural process carried out by earthworms in meeting their life needs, including behavior in making the hole, so that the activity of making it does not require resources for making and maintaining it.

Table 1. Number and Diameter of Earthworm Biopore Infiltration Holes.

No	Plot	Number of holes (fruit)	Hole diameter (mm)									Ave. (mm)
			1	2	3	4	5	6	7	8	9	
1	I	5	4	6	5	3	4					4,40
2	II	6	4	4	4	5	4	3				4,00
3	III	4	5	5	4	5						4,75
4	IV	6	4	5	4	6	4	4				4,50
5	V	2	4	5								4,50
6	VI	7	3	4	5	5	4	6	4			4,43
7	VII	4	5	6	4	4						4,75
8	VIII	7	4	7	4	6	5	6	6			5,43
9	IX	6	5	6	6	4	5	4				5,00
10	X	5	5	4	6	4	4					4,60
11	XI	3	5	5	4							4,67
12	XII	4	3	6	4	4						4,25
13	XIII	5	4	5	6	4	4					4,60
14	XIV	3	5	4	5							4,67
15	XV	6	4	4	4	5	6	5				4,67
16	XVI	8	5	5	5	4	5	4	4	5		4,63
17	XVII	6	4	4	5	5	4	4				4,33
18	XVIII	8	4	6	5	4	4	3	5	6		4,63
19	XIX	9	5	5	5	5	4	4	6	3	6	4,78
20	XX	3	3	5	4							4,00
AVERAGE		5,35										4,58

In the study, the average diameter of the earthworm biopore infiltration hole was 4.58 mm. If the earthworms dig the soil to a depth (length) of 100 cm, then the earthworm biopores are able to expand the groundwater infiltration area by 143.9429 cm2 from 0.164815 cm2, or expand the infiltration area by 873 times from the water infiltration on the ground surface. The hole is able to accommodate 0.0165 liters of water/worm/hole (Table 2.), provided that the hole is made without branches.

Table 2. Comparison of Biopore Infiltration Holes (LRB) according to Brata and Nelistya **[3]**) with Earthworm Biopore Infiltration Holes (LRBCT) Research Results

Infiltration hole type	Diamete r hole (cm)	Depth (cm)	Circumnavigating the circle (cm)	Hole mouth area (cm2)	Wall area (cm2)	Expand the material (kali)	Water Volume (litre)	Source
LRB	10	100	31,4286	78,5714	3142,8571	40	7,8571	(Brata and Nelistya . 2002).
LRBCT	0,458	100	1,4394	0,1648	143,9429	873	0,0165	Results

According to Hanafiah et al. **[12]**, tunnels made by Lumbricus terrestris can reach a depth of 150-240 cm vertically and have many branches near the ground surface. Dramida grandis can dig tunnels to a depth of 2.7–3.7 m. If calculated with a diameter of 4.58 mm with a depth of 3.7 m (370 cm) and no branches, then the earthworms are able to expand the groundwater absorption area by 532.5886 cm2 from 0.1648 cm2, or expand the groundwater absorption area 3231.4 times from water absorption on the ground surface. The earthworm holes are able to fill groundwater by 0.06098 liters/wormhole. From the research results, the number of earthworm holes for every 2,500 cm2 of land area was an average of 5 holes. The number of holes found was at least 2 holes (plot V) and at most 9 holes (plot XIX). So in every square meter there are 20 holes. If the ability of earthworms is 0.0165 liters/worm/hole, then for every square meter of land area earthworms can help put water into the soil by 0.33 liters or 330 ml. According to Murie **[13]** worm holes are characterized by the presence of dirt around the hole. This was also found during observations in the field, most of the holes were covered by worm dirt. This condition is often found in the rainy season or humid environments (for example near gutters) or bushes. In the dry season or in dry places, worm holes are clearly visible, and usually there is less dirt covering them. It is also seen that in worm holes there is a succession of residents in the form of ants or ground beetles. According to Hanafiah et al **[12]**, tunnel-digging earthworms release organic compounds containing pheromones, which are chemical compounds that function as distinctive markers of the type of tunnel-digging worms. Lumbricus terrestris produces pheromones (which attract attention), so that it acts as a trigger for other fauna to use the tunnel as their habitat, and fill it with a source of nutrients that are also useful for earthworms. This is what causes the Lumbricus terrestris tunnel to be used permanently. Thus, it is possible for other animals to be in the earthworm biopore infiltration holes.

Earthworms can also improve the biological conditions of the soil, according to Hanafiah et al **[12]** and Hardin **[8]**, stating that the presence of earthworm holes causes the soil aeration and drainage system to improve, so that the availability of oxygen for aerobic microbial activity and chemical oxidation reactions in the soil improves, which will ultimately improve soil fertility biologically and chemically. Earthworms are so important in improving groundwater that it is necessary to make efforts to increase the population in a location by adding earthworms or providing the necessary environmental facilities. The selection of earthworm types needs to be done, so as not to make the wrong choice. The types of worms from the endogeic and anesic groups are the types that are most suitable for making groundwater infiltration holes (earthworm biopore infiltration holes), while the epigeic group is not suitable for making water infiltration holes.

IV. CONCLUSION

Based on the research results, it can be concluded that, The average earthworm biopore infiltration hole has a diameter of 4.58 mm and there are 20 holes in every square meter. If it is estimated that each worm digs the soil to make a hole one meter deep, then the earthworm biopore infiltration hole can expand the groundwater infiltration area 873 times/hole.

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