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Analysis of Shallow Groundwater Quality as Consumable Water in Maros Baru District Aquifer Systems, South Sulawesi, Indonesia

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Abstract

Water is a source of necessity for humans. Water quality is very important to be considered as the source of clean water. Some people in Maros Baru District use ground wells as the source of water needs. Therefore it is important to know the physical quality and pH level of shallow wells and to know the worthiness of shallow wells in Maros Baru District with reference to Permenkes No.492/ 2010. This study examined the feasibility of water based on the physical quality and the pH level of water taken from shallow wells. The research was carried out directly in field with 14 sampling points scattered in the north, east, south, west and at the center of field. The method in observing pH value is by litmus paper and observation on the physical condition of water, well depth, well diameter and surface level of water. The result shows there were 2 locations with saltwater taste, as the location is near from the sea and rivers, while turbidity of the water influenced by condition of surround environment that was not properly maintained. From data processing, it can be concluded that as many as 5 of the 14 sampling points did not meet the eligibility standards of Permenkes No.492/2010 to be used as a source of clean water intended for drinking water.

Keywords: shallow groundwater; water physics parameters; water pH; quality; consumable water

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INTRODUCTION

Water is a natural resource that is very important for the survival of all living thing, especially humans. Every day, humans use water for daily needs such as: drinking, cooking, washing, and watering plants (Adimalla, N. 2013). Water sources are susceptible to contaminants, as well as groundwater which can be contaminated by many factors, one of them is microbiological factors (Prilia and Kamil, 2011). World conservation experts predict that by 2025 world's population will have difficulty in accessing clean water (Zazili, 2008 in Indrawan, 2016).

Along with the rapid development of technology and population, development progress in all aspects of human life, the fulfillment against water resource needs is also increasing. One of the aspect that affects groundwater potential is the geological condition of an area (Umar et al., 2019).

Increment of natural resources is very important in maintaining the continuity and balance of people's lives including the sufficiency of water resources (Nawir and Umar, 2018). One of the sources of irrigation water is ground water (Adimalla, N., & Venkatayogi, S. 2018). Groundwater is one of water resources whose volume and existence is limited, and its damage can have a wide impact, recovery efforts are difficult and expensive to be performed (Darwis, 2014). Groundwater is water contained in layers of soil or rocks below the ground surface (Karimuddin et al., 2018).

Ground water is a necessary need for society. The increasing number of residents along with the growing clean water demand, makes maintenance of groundwater quality become a necessity (Yuliani et al., 2019). Groundwater is part of rainwater that reaches the earth's surface and seeps into the soil layer and becomes ground water (De et al., 2008). Before reaching the groundwater aquifer, rainwater penetrates several layers of soil and cause the water to contain mineral substances in certain concentrations. These mineral substances include calcium, magnesium and heavy metals such as iron (Chandra, 2007 in Mashadi et al., 2018).

Groundwater can be either deep well water or shallow well water. Ground wells or shallow wells are the most common and widespread constructed wells used to extract groundwater for community's clean water needs and also can be used as drinking water with an average depth of 7 to 10 meters and not more than 15 meters from the ground surface (Umar and Nawir, 2018). Ground wells provide water that comes from a layer of soil that is relatively close to the ground surface, therefore it can be easily contaminated (Al-ahmadi, M. E., & El-Fiky, A. A. 2009). Drilled wells (pumps) or deep groundwater are layers of groundwater that are drilled deeper or layers of soil that are far from the ground surface and difficult to reach, therefore slightly affected by surface contamination, commonly the depth is more than 15 meters (Suryana, 2013 in Ningrum, 2018).

There are many benefits of groundwater those have been described and experienced by humans. It would be nicer if ground water could be protected from pollution and also conserved through conservation of ground water (Carneiro et al., 2010). Preservation of groundwater can be done by making rainwater infiltration wells and reducing the production of groundwater polluting waste (Chandrasekar et al., 2014). If the existence of ground water is maintained then human survival will also be protected (WHO. 2004). Samples of clean water providers are carried out from existing surface water reservoirs and rivers (Hadimuljono, 2019).

Maros Regency, precisely in Maros Baru District, is one of the areas in South Sulawesi which has fairly rapid regional development including the growth of community needs which is increasing day by day. The fulfillment of clean water needs is a very important effort in order to maintain the health of surrounding environment. Therefore, this study was performed by physically analyze water quality then provide recommendations regarding ground well water or shallow groundwater that is suitable for clean water and drinking water for the community in the research area.

METHOD

The research is performed in Maros Baru District, Maros Regency, South Sulawesi Province. New Maros Subdistrict has 7 (seven) administrative divisions with details of 3 (three) major-villages i.e : Baji Pamai, Baju Bodoa, and Pallantikang Villages and 4 (four) minor-villages which are Borikamase, Borimasunggu, Majannang, and Mattirotasi villages **(Figure 1)**.

Collecting data in form of primary and secondary data. Primary data is obtained directly from research environment in form of ambient air temperature, water pH (using litmus paper), colour, taste, smell, and turbidity, the weather, well depth and diameter, water level, interview and villages pictures. The interview process for well owners were carried out in order to obtain information about the depth of well and problems that usually occur in relation to the well. Position coordinates were taken by plotting the location of shallow wells using Google Earth. Data retrieval is taken in areas that represent the north, east, south, west and central directions. However, in the west direction, to be precise in the northwest, no sampling was carried out due to land condition of the area was mostly rice fields and there were no well or shallow groundwater (shallow wells) was built within the areas. For secondary data, in form of literature reviews which are related to this study.

The data obtained in the field are in raw data form, both primary data and secondary data, then processed based on the type of data. The obtained or processing were then analysed and matched to the main reference of PERMENKES No.492/2010.

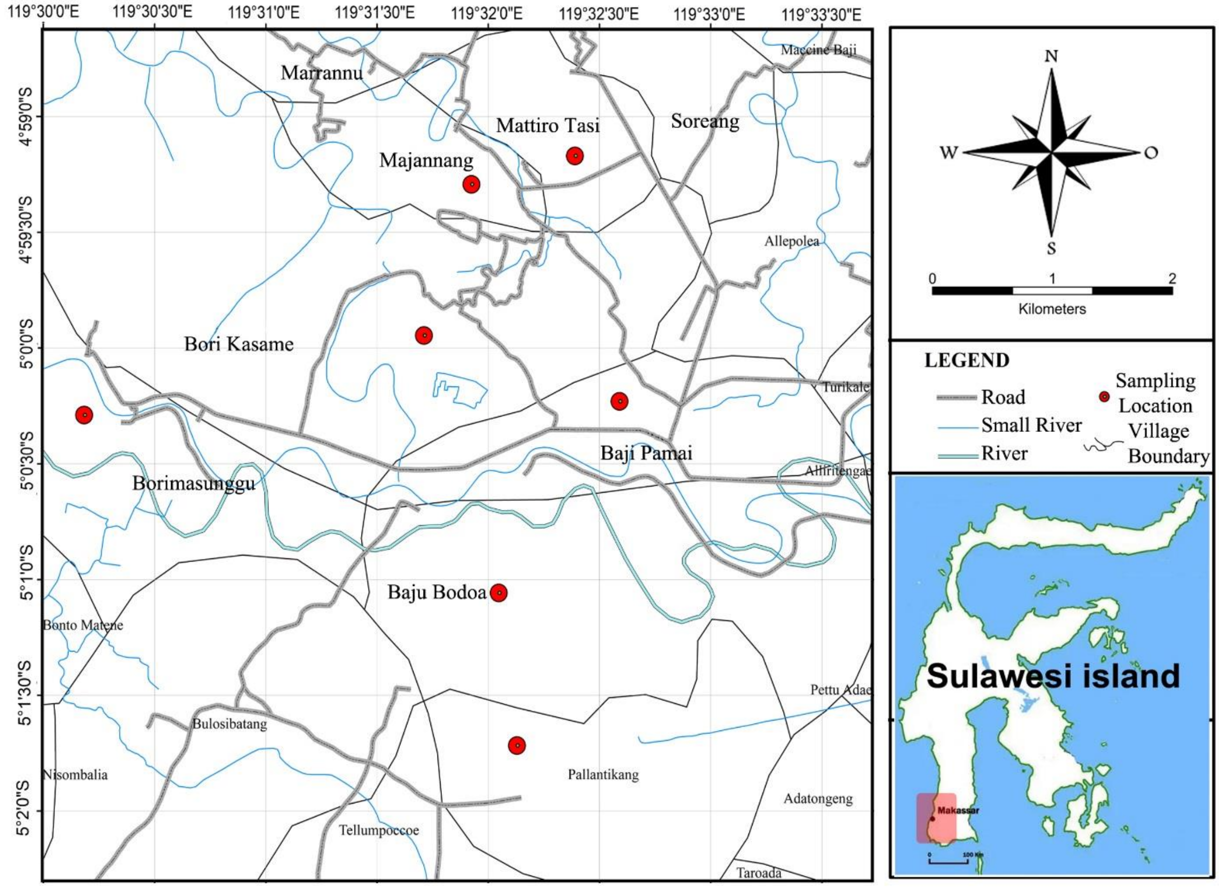

Figure 1. Map of Research Locations

RESULTS AND DISCUSSION

Geological Condition of Research Area

The research area of Maros Baru District, Maros Regency has an Alluvium flat unit located in the western part, spread in north-south direction, occupying about 25% of the total area of Maros regency. It is characterized by a flat topographic morphology, low relief, smooth texture with alluvium sedimentary bedrock. Soil types in Maros regency are classified into four types. In the research area, Maros Baru District has young Alluvial soil type. Young Alluvial is an Alluvial deposit (alluvial deposit of rivers, beaches and swamps) of young (recent) age and occupies a plain morphology area with a height of 0-60 meters by slope angles of < 3%. Textures vary in size from clay, silt, sand, gravel, to gravel with a high fertility level.

Maros Baru District has 7 sub-districts or villages. To fulfill their daily needs of water resources, the people in Maros Baru District mostly use clean water produced by the clean water service of the Municipal Drinking Water Company (PDAM). However, not some people remain use ground wells or shallow wells as a source of clean water, as the clean water services from PDAM have not fully covered all areas in Maros Baru District. Meanwhile, the use of drilled pump wells is not possible due to relatively high costs for small communities, so most local people use ground wells. Problems that occur in people who use ground wells are mostly not knowing whether the well water is useable or not as source of clean water or drinking water for daily needs.

Physical Quality and pH Level of Shallow Wells Water

Based on observations and sampling of shallow wells Maros Baru District, several wells were varies in terms of the quality, physical properties and pH level. The physical properties of the well water can be seen in **Table 1**.

Table 1. Parameters of physical properties and pH level of shallow wells water

No	Station	Parameters of Physical Properties				pH
		Colour	**Odour**	**Taste**	**Turbidity**	
1	ST1	Colourless	Odourless	Salty	Turbid	6
2	ST2	Colourless	Odourless	Salty	Clear	6
3	ST3	Colourless	Odourless	Tasteless	Cloudy	7
4	ST4	Colourless	Odourless	Tasteless	Cloudy	7
5	ST5	Brownish Yellow (tawny)	Odourless	Tasteless	Cloudy	7
6	ST6	Colourless	Odourless	Tasteless	Clear	7
7	ST7	Colourless	Odourless	Tasteless	Clear	7
8	ST8	Colourless	Odourless	Tasteless	Clear	7
9	ST9	Colourless	Odourless	Tasteless	Clear	7
10	ST10	Colourless	Odourless	Tasteless	Clear	7
11	ST11	Colourless	Odourless	Tasteless	Clear	7
12	ST12	Colourless	Odourless	Tasteless	Clear	7
13	ST13	Colourless	Odourless	Tasteless	Clear	8
14	ST14	Colourless	Odourless	Tasteless	Clear	8

(**Source :** Data of this study)

The difference in physical properties is caused by the differences of the surrounding environment. To the west of the study site, there are ST1, ST2, ST3, ST4, ST8 and ST9 **(Figure 4)**. The average depth of shallow wells in this direction is 3-5 meters. They have average well diameter of 60-70 cm and water level of 180 to 290 cm. At locations ST1 and ST2 both have pH values of 6 with physical properties that are colorless, odorless, and salty taste. Sampling of water is only on the surface, the difference between ST1 and ST2 is only in terms of the location of the well, ST1 is in an open space so that it is directly exposed to sunlight while ST2 is indoors. Measurement of pH and observation of physical properties of shallow wells as shown in **Figure 2**.

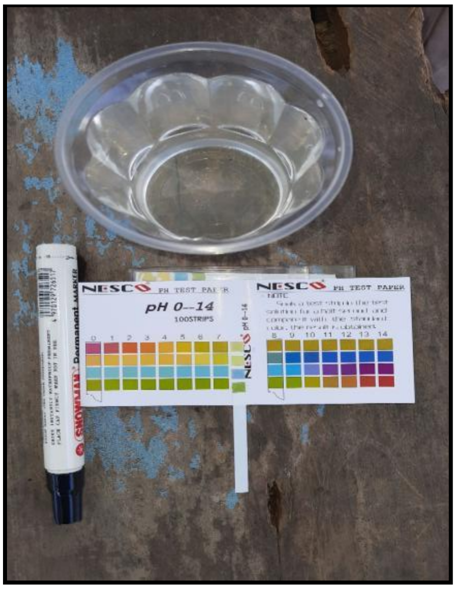

Figure 2. Measurement of pH and Observation of Physical Properties of Shallow Wells

The salty taste comes from water in ST1 with 5 meters depth while ST2 with 4 meters depth due to the location is close to open sea and rivers. Seawater comes from rainwater that flows through rivers and eventually empties into the sea, which will evaporate into clouds and fall back into rain. Throughout the process, water flowing through rivers carries salts mineral such as potassium, calcium, sodium and others. These salts mineral are obtained from rocks and the earth's crust which is passed along the flowing water. When it reaches the sea, the salts mineral remain while the H_2O evaporates into clouds. The remaining mineral salts are what make sea water salty. This salty seawater flows into the aquifer layer which causes the water in the well tastes salty. At ST1 location the water was cloudy, in contrast to ST2 location where the water was clear.

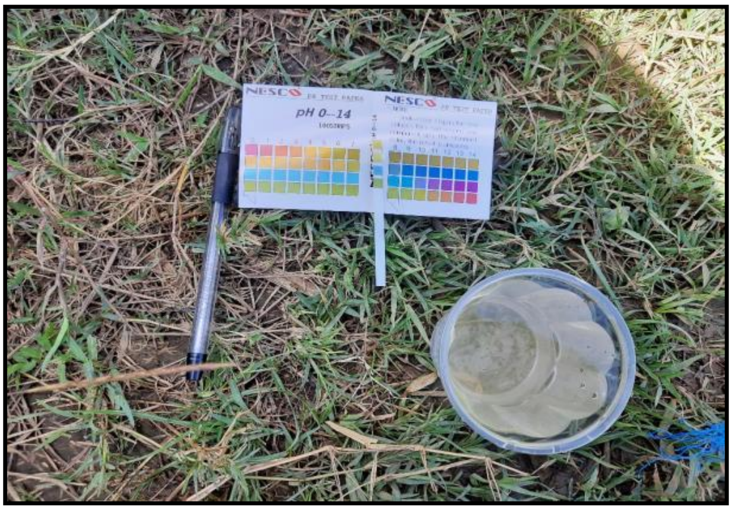

Figure 3. ST5 Shallow Well Physical Condition

This is because ST1 is within radius 4 meters from nearby an old ground well functioned as a garbage dump of surrounding community where leachate from the waste pollutes the water quality around ST1. This is different from ST2; the water is clear as ST2 well is inside a resident's house, with low level of pollution and less dissolved substances such as clay within the earth water source. Water in shallow wells in ST2, by refers to the pH level, it could be directly used as source of drinking water, however does not meet other requirements to be used as drinking water, therefore treatment must be carried out in form of distillation to produce healthy fresh water.

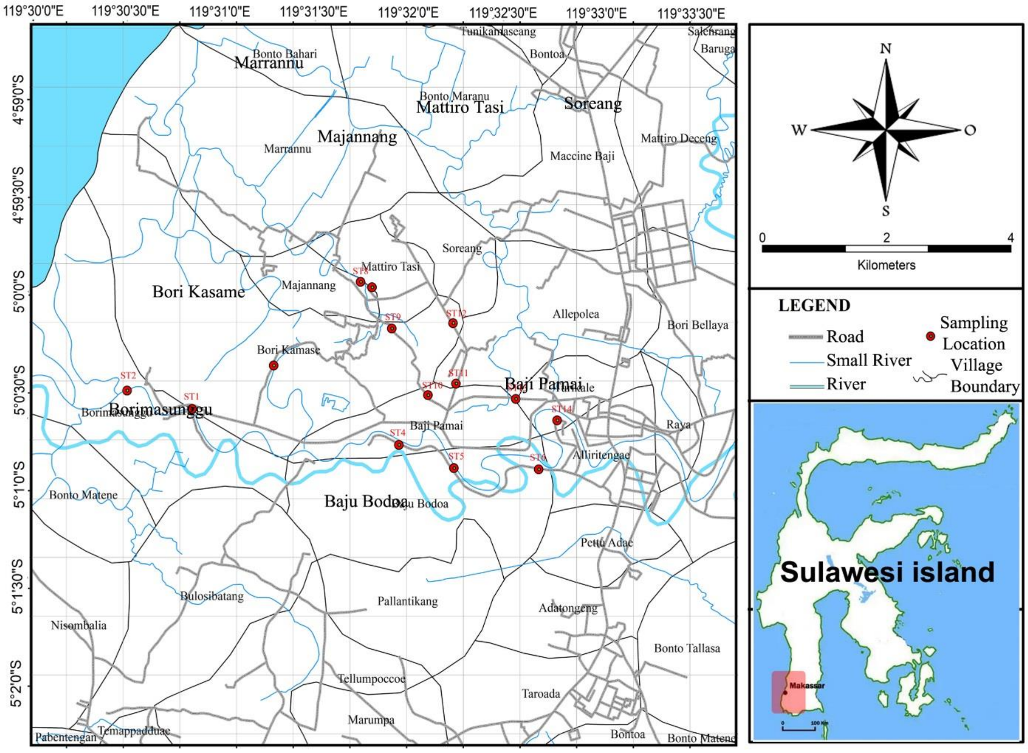

Figure 4. Map of locations for observation and sampling of water

To the south location, there is ST5. Shallow wells at ST5 were placed in open space and water sampling were performed on the ground. The well has 5 meters depth, pH of 7 with physical properties of water color is brownish yellow, odorless, tasteless, and the level of turbidity is cloudy.

The brownish-yellow and cloudy water occurs at this location is due to the large amount of dissolved clay in the well. The physical condition of shallow wells ST5 can be seen in **Figure 3**.

In the East direction of the research location, there are ST6, ST11, ST13 and ST14 **(Figure 4)**. These four locations are in open spaces, exposed directly to sunlight. At this location, water sampling was only on the surface, the shallow wells water had physical properties of colorless, odorless, tasteless and had a clear level of turbidity. The physical condition of the water is due to the fact that the surrounding environment is quite clean. The North direction which represents the research location of ST12, and the center point of the research location is represented by ST10, can be seen in **Figure 4** (Map of observation location and water sampling). Both of these locations are in an open space. Sampling of water is only on the surface, has the same pH of 7 and has the same physical properties of shallow wells, namely colorless, odorless, tasteless and clear turbidity. The surrounding environmental areas were also very clean.

The type of soil found in Maros Baru District is mostly alluvial soil. This type of soil can affect water quality because of the large amount of sedimentary materials mixed in it (Brindha, K., & Elango, L. 2012). One of the influencing factors during sampling is temperature as it affects the water surface level. If the air temperature is high then the water level will be lowered as evaporation rate is high. Other consideration is when it is going to be rain or have just rain. Rain affects the level of acidity of the water, moreover, this condition affects the turbidity of well water. When it rains, the precipitated clay will mix again and make the water cloudy. The average temperature at the time of water sampling of this study site were ranged from 32 to 33 ^{o}C.

Eligibility of Shallow Wells Based on Regulation of the Minister of Health of Republic of Indonesia, No.492/MENKES/PER/IV/2010

The feasibility of shallow wells in Maros Baru District, Maros regency which is categorized based on the Regulation of the Minister of Health of the Republic of Indonesia, includes acidity level (pH), Odor, Taste, Turbidity and Colour. In acidity level (pH), based on the Regulation of the Minister of Health of the Republic of Indonesia No.492/MENKES/PER/IV/2010 the mandatory parameters for water quality are ranged from pH of 6.5 to 8.5. The results of the study in **Table 1** show pH values of 6 to 8 at the study site. By the above standard, the pH parameter is categorized as suitable for use as clean water. Odour is one of the parameters of the physical properties to determine the quality of shallow wells. In accordance with the standards of the Regulation of the Minister of Health of the Republic of Indonesia No.492/MENKES/PER/IV/2010, water is suitable for daily use and consumption if it is odorless. All water from the observed water sample were odourless.

Taste is one of the parameters of the physical properties to determine the quality of shallow wells. From the observations there are two wells that taste salty water. Precisely at the location ST 1 with coordinates 5.004437°S 119,511078°E. It is 5 m depth, with water level of 180 cm and 67 cm in diameter. ST2 located in coordinates 5.000340°S 119,502610°E, it is 4 meters depth, water level of 163 cm and 66 cm in diameter. Both locations have water that tastes salty because they come from locations close to the sea shore and Maros river. Sea water flowing through rivers carries mineral salts such as potassium, calcium, sodium and others. This seawater makes well water salty, In contrast to the taste parameters standard No.492/MENKES/PER/IV/2010 which is should be tasteless. In Turbidity, water is said to be cloudy if the water contains so many suspended particles of material that gives dirty color or appearance. Materials that invest to water turbidity include clay, silt, or organic materials that are dispersed from small suspended particles. From the observations, there were four wells with cloudy water, namely ST1, ST3, ST4, and ST5. ST1 is located exactly at the coordinates of 5.004437°S 119,511078°E, 5 meters depth, water level of 180 cm and diameter of 67 cm. The condition of surrounding environment affect the water source, there are used ground well functioned as a garbage dump by the surrounding community. The leachate from the waste seeps into the ground contaminating the aquifer which is suspended by the particles and passes through. ST3 is located at the coordinates of 4.999973°S 119.521008°E, has depth of 5 meters, a water level of 198 cm and diameter of 73 cm. ST4 is located at the coordinates of 5,006655°S 119,536486°E, has depth of 5 meters, water level of 224 cm and diameter of 69 cm. ST5 is located at coordinates of 5.010101°S 119.543703°E, has depth of 5 meters, water level of 246 cm and diameter of 99 cm.

Color is one of the parameters of the physical properties to determine the quality of shallow wells. There are two colors of well water obtained at the research site, namely clear (colorless) and brownish yellow. The location of the yellow-brown well is at ST5, precisely at coordinates 5.010101°S 119.543703°E with depth of 5 meters, water level of 246 cm and diameter of 99 cm. This is due to the large amount of dissolved clay in the well and the soil around the location is brown. Areas or locations whose clean water source are suit the regulation of the Minister of Health of the Republic of Indonesia No.492/MENKES/PER/IV/2010 in Maros Baru District, Maros Regency, South Sulawesi Province are located in the center to north and to east. For areas whose water source not suitable for use as clean water and drinking water is from south to west along the Maros river basin **(Figure 4)**.

CONCLUSION

This study demonstrates that the physical characteristics of shallow groundwater from household wells in the study area vary considerably, particularly in terms of color and turbidity, although the water is generally tasteless and odorless. These variations are largely attributed to inadequate sanitary conditions surrounding the wells. The measured pH values of the shallow groundwater range from 6 to 8, indicating slightly acidic to neutral conditions. Based on the Indonesian Ministry of Health Regulation No. 492/MENKES/PER/IV/2010, five out of fourteen sampling locations do not meet the required standards for use as drinking water. These non-compliant wells are predominantly located along the Maros River corridor, extending from the southern to western parts of the study area. In contrast, groundwater that meets drinking water quality standards is mainly distributed in the central, northern, and eastern sectors of Maros Baru District. Although several sampling sites satisfy the regulatory criteria, it is recommended that shallow groundwater be treated prior to consumption. Simple treatment methods such as filtration and sedimentation are advised to improve water quality and ensure its safety for domestic use.

AUTHOR CONTRIBUTIONS

Conceptualization, EPU and HMP; methodology, AN; software, NJ; validation, JP, WJ, and EPU; formal analysis, HMP; investigation, AN; resources, NJ; data curation, JP; writing—original draft preparation, EPU; writing—review and editing, HMP; visualization, AN; supervision, NJ; project administration, EPU; funding acquisition, EPU.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest concerning the publication of this article. The authors also confirm that the data and the article are free of plagiarism.

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