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DOMESTIC SUPPLY WATER AND SANITATION PRACTICES IN THE PERI-URBAN AREAS - CASE STUDY OF PLEIKU CITY

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Abstract

Protecting water sources is an essential issue for ensuring the supply of clean water to people. Many human activities are affecting the water sources in households. This study conducted face to face interviews on 169 households in order to analyze the current status of domestic water supply and environmental sanitation practices in peri - urban areas of Pleiku city. The Focus Discussion Group method was also used to assess stakeholder participation in implementing measures in improving water sources and sanitation. The results showed that most of the households are using groundwater for daily domestic purposes because the municipal water supply system has not been installed in the studied areas. In addition, most households are satisfied with the quality of existing groundwater. However, the lack of water and some problems of water quality sometimes occur in the dry season. In order to protect groundwater, waste and wastewater from livestock and agricultural activities should be controlled.

Keywords: Pleiku; Peri - urban areas; Sanitation; Supply water; Clean water

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1. Introduction

Safe drinking water, sanitation and hygiene play a key role in maintaining a healthy life. Access to clean water and sanitation is a fundamental human right recognized by the United Nations (United Nations, 2010) [1]. Fifty percent of the world's population is expected to live in urban areas by 2050. Due to rapid urbanization, especially in developing countries, the mechanisms and basic infrastructure have not kept pace with unprecedented growth (McConville and Wittgren, 2014) [2]. The peri - urban area has both rural and urban characteristics and it refers to the movement of goods and services between physical spaces and the transition from rural to urban contexts as a process and an interface between rural and urban activities, institutions and perspectives (Marshall et al., 2009) [3]. The problems in peri-urban areas are encountered in the process of urbanization such as loss of agricultural land, natural landscape or lack of access to infrastructure and basic services (Allen et al., 1999) [4].

Urban expansion has had many impacts on environmental degradation. Green belts and ecological corridors of urban areas can be significantly impacted (Torres et al., 2007) [5]. Basic infrastructure in peri-urban areas has not met the growing population's demand in urbanized areas, which could cause environmental problems such as waste and wastewater pollution due to a lack of environmental infrastructure. In addition, untreated waste and wastewater are discharged into the environment, causing serious pollution from domestic, agricultural and industrial activities (Thang, 2009) [6]. During the transition from rural to urban areas (intersectional areas), there would be many problems such as mechanisms and policies, lack of technical infrastructure and clean water sources (Yankson and Gough, 1999) [7]. In general, peri - urban areas are affected by urbanization and the rate of agricultural activities is decreasing and being replaced by non-agricultural production activities. Furthermore, urbanization could affect groundwater quality and levels due to the over - exploitation of groundwater (Tam and Nga, 2018) [8].

Groundwater used for domestic water supply is popular. However, pathogen contamination is often associated with a lack of improved sanitation and inadequate understanding of the processes of attenuation of disease agents (Schmoll, 2006) [9]. According to recent data, the rate of access to clean water and sanitation has improved significantly, but in rural areas, the rate is still relatively low compared to urban areas. Also, there is a significant disparity between access to clean water between the rich and the poor households (World Bank, 2014) [10]. Children can be affected if water and sanitation conditions are poor and this has been confirmed by previous studies (Checkley et al., 2004) [11]. The current situation of poor sanitation and drainage is taking place in peri - urban areas (Hui and Wescoat, 2019) [12]. Meanwhile, Pleiku city of Gia Lai province is located in Highland of Vietnam and many minority ethnic groups are needing to consider in this study. According to the rural water and sanitation in Gia Lai province, the rate of rural households using improved water is 91.32 % and the proportion of the poor using improved water is only 77.69 %. Moreover, the rate of rural people using clean water that meets national technical regulations is only 43.80 %. In terms of rural sanitation, the percentage of households with toilets reached 70.63 % and the household rate with hygienic latrines is only about 51.16 % and the poverty rate has hygienic latrines only reached 16.97 % (Gia Lai People's Committee, 2017) [13]. Therefore, assessing the current situation of a domestic supply water system, storage and treatment and the surrounding environmental sanitation practices are very important to implement solutions to prevent water pollution, which contributes to protecting public health.

2. Methodology

2.1. Studied area

The study was carried out in 3 peri - urban communes including Ia Kenh, Chu A and Bien Ho of Pleiku city, Gia Lai province. Population characteristics in the studied area are shown in Table 1, in which the rate of ethnic minorities is equal to 20 - 35 % of the total population, mainly Jrai and Ba Nar ethnic groups.

Table 1. Population characteristics of studied area (Gia Lai Statistical Office, 2019) [14]

Commune	Area (Km^2)	Population (person)	Minority ethnic groups		
			Jrai	Ba Nar	Other groups
Ia Kenh	33.03	9,160	2,751	0	0
Bien Ho	20.19	8,856	1,644	6	89
Chu A	14.77	17,649	4,720	1,632	0

2.2. Workflow of the study

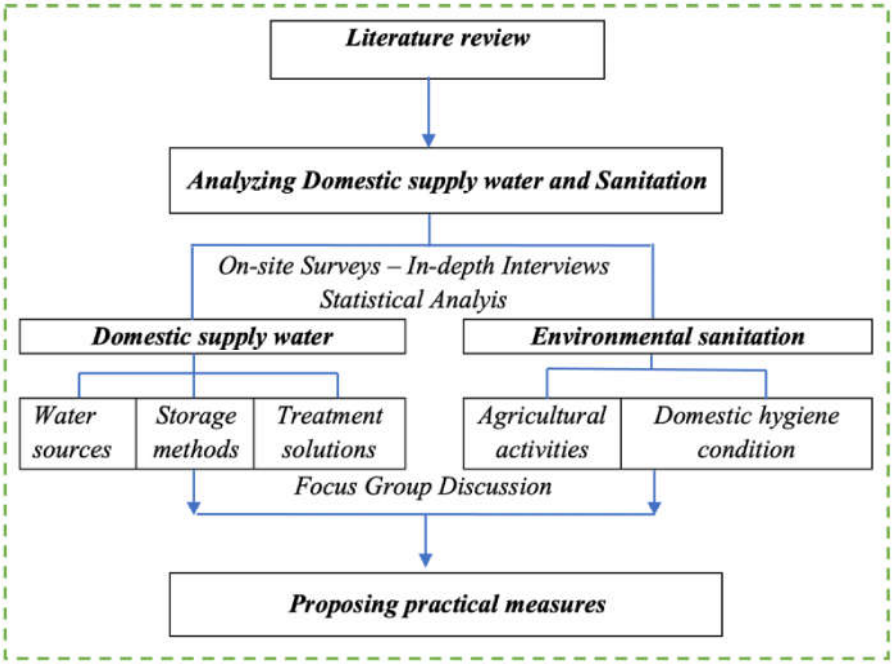

Figure 1: Research framework

The methods were used to conduct the survey including face to face interviews and closed - ended questionnaires. In this study, we surveyed the households in three Hamlets/Villages belonging to three peri - urban communes of Pleiku city, Gia Lai province. The current status of domestic supply water in households (e.g. water quality, sources, etc.) and the sanitation practices (e.g. storage and treatment solutions, etc.) are examined to improve the health issues. The data were collected by using systematic random sampling techniques. The locations of households were recorded with GPS coordinates and represented by QGIS software. The sample size is determined by the following formula [15].

$$n = \frac{N}{1 + N \times e^2}$$

Where: N = 8,916 (the total number of households), e = 0.1 (the margin of errors) (10 %).

It is necessary to interview about 99 households. However, the research carried out a survey of 169 households (according to the framework of the project of Nong Lam University of Ho Chi Minh City). A total of 169 households were sampled from peri - urban areas including 50 households (Ia Kenh commune), 50 households (Bien Ho commune) and 69 households (Chu A commune) (Tab. 2).

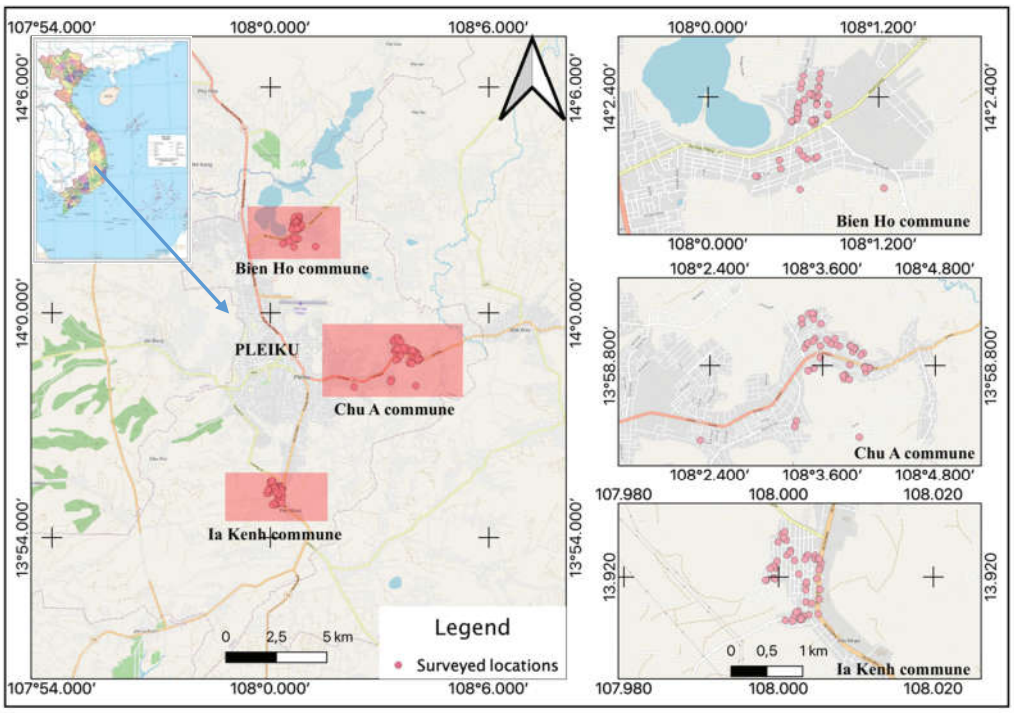

Figure 2: Map of Pleiku city and the studied area

Demographic characteristics are shown in Table 2, in which more than 60 % (n = 102) are male and nearly 40 % (n = 67) are female. In terms of education level, nearly 90 % (n = 152) are literate, only about 10 % (n = 17) have no formal education. As the study areas are the peri - urban area of Pleiku city, agriculture activities dominate the families' occupation. More than a quarter of the people surveyed is working as a farmer at home. All surveyed people have low-income levels from 1,000,000 to 5,000,000 VND, accounting for 66.86 % (n = 139) and from 5,000,000 to 10,000,000 VND, accounting for 33.14 % (n = 56).

A semi-structured interview schedule consisting of 47 questions was used as the studying tool. The interview structure is divided into three parts and the first part includes basic information. This section aimed to obtain information on the socio - demographic profiles including age, gender, education, occupation, income, marital status, a number of family members, etc. The second part was designed to identify the levels of the public's awareness about using clean water (the role of clean water for health, forms of access to information on safe water use, perception of negative impacts when using unsafe water, feeling water quality, etc.). The third part was divided into three groups (information on supply water, information on sanitation conditions and, assessment of advantages and disadvantages in using clean water).

The focus discussion group method was used to assess the level of participation in implementing solutions to improve the supply of clean water and sanitation. Based on Stanghellini's classification system and the previous study in Pleiku city (Stanghellini, 2010; Anh et al., 2019) [16, 17], experts consultation (three experts) is employed to clarify the level of stakeholder involvement.

Table 2. Demographic characteristics in the surveyed respondents

Socio - demographic variable		No. of respondents (n)	Frequency (%)
Gender	Male	102	60.36
	Female	67	39.64
Education	None	17	10.06
	Primary school	43	25.44
	Secondary school	57	33.73
	High school	45	26.63
	College/university	7	4.14
Occupation	Self-employed	16	9.47
	Government Officer/ wages	10	5.92
	Agriculture	139	82.25
	Private sector	2	1.18
	Freelancers	2	1.18
Income (VND)	1,000,000 - 5,000,000	113	66.86
	5,000,000 - 10,000,000	56	33.14
	10,000,000 - 15,000,000	0	0
	> 15,000,000	0	0
Age (years old)	18 - 30	21	12.43
	31 - 40	80	47.34
	41 - 50	30	17.75
	51 - 60	25	14.79
	> 60	13	7.69

Data was illustrated with average (± SD) and frequency (%). These values were calculated on used water sources, the satisfaction of water quality, materials of storage facilities, water treatment methods, types of toilets and distance to water sources, livestock barns and the distance to the water sources. Also, this study examined the current status of domestic supply water (e.g., smell, color, turbidity, safe level, etc.) during the rainy and dry seasons using paired t-tests at a significance level of $p < 0.05$. All the statistical parameter tests were obtained using SPSS 21 for Windows.

3. Results and discussion

3.1. The current status of domestic supply water

Water - related diseases are one of the world's leading concerns (Schmoll, 2006; WHO, 2016) [9, 18]. Open wells are often more susceptible to pollution than bore wells because overflows can penetrate more quickly (Seifert - Dähnn et al., 2017) [19]. According to our findings, water sources in the peri-urban areas of Pleiku are mainly groundwater (dug/open wells and bore wells). The results showed that 164 of 169 households in three communes used groundwater as a main source of water for domestic purposes. Of which, 154 households (93.9 %) used dug/ open wells and 10 households use bore wells (6.1 %). In addition, up to 43.8 % (n = 74) households confirmed that the water source quantity is unstable, especially in the dry season from March to May annually. When the households could not access water or be unsafe, they must use alternative sources such as fetching water from the public spaces (bore wells and pre - treatment system) or shared with households with other wells.

Table 3. Feeling assessment of current domestic supply water

Issues	Rainy		Dry		Paired T - test	
	Mean	Std. Deviation	Mean	Std. Deviation	t	P value
Smell	4.8259	0.32601	4.4108	0.15207	2.646	0.036
Color	4.7073	0.58556	4.0127	0.21846	3.218	0.001
Turbidity	4.5448	0.29921	4.1202	0.31391	2.867	0.027
Safety level	4.0037	0.59819	4.3593	0.59819	-2.956	0.020

Table 3 describes the average values of surveying the feeling level of smell, color, turbidity and safety of domestic water in the rainy and dry seasons. In which, the assessment of smelly water in the rainy and dry seasons with the average value of 4.8259 (SD = 0.32601) and 4.4108 (SD = 0.15207), respectively. The difference in the value of odor assessment in water in different seasons was also confirmed through the T - test analysis.

In addition, the community's perception of safety level showed that the level of satisfaction with domestic water supply is quite high. The results also reveal that the safety levels of water quality in the dry season are higher than those in the rainy season ($p < 0.05$). Thus, it can be seen that although the water sources have occurred some problems related to smell, color,... the people's positive evaluation and acceptance are also expressed by the level of satisfaction.

Most of the families are quite satisfied with the water quality, only 3 % (n = 5) are not satisfied with the water quality, especially in the dry season. This finding is also consistent with the previous study of microbiological risks in groundwater [20]. However, the study also showed that current risks of microbial contamination of water are related to livestock and farming activities in households. Some other studies revealed that groundwater could be contaminated with microorganisms and heavy metals (arsenic, iron, etc.) due to impacts from agricultural, industrial activities and domestic wastewater (Nguyen et al., 2020; Phan and Nguyen, 2018) [21, 22].

The risks of domestic water contamination during the use and storage process depend on many factors such as storage materials, distribution system, weather conditions,... According to the results, the households often use water storage tanks of about 0.3 - 2 m^3. This may cause external contaminants during the duration of water storage (Ravindra et al., 2019) [23]. Furthermore, 14.8 % (n = 25) of households reported using plastic containers to store water. Containers are made of other materials such as 55 % of stainless steel (n = 93), 23.1 % of aluminum (n = 39) and 7.1 % of iron (n = 12). Storing water in plastic containers will facilitate the accumulation of biofilms and promote microbial growth, leading to the deterioration of water quality (Machdar et al., 2013; Ravindra

et al., 2019) [23, 24]. The length of storage time is also an important factor that contributes to water pollution and the long duration of water storage can significantly increase the level of health risks (Brick et al., 2004) [25].

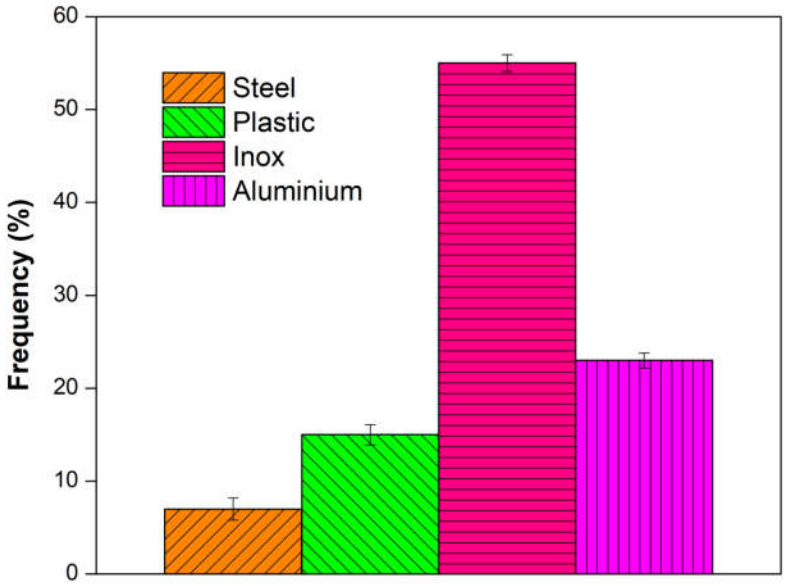

Figure 3: The materials of storage tanks

Figure 4: Dug/open wells at Nhao 2 village

Figure 5:Water storage tank at Nhao 1 village

Regarding water quality protection and pre-treatment approaches, most households (about 90 %, n = 152) carried out natural sedimentation and only about 10 % (n = 17) of households used activated carbon filters to treat water. All families boiled raw water before using it for daily purposes (e.g. drinking). It can be seen that the practice of boiling improves the microbiological quality of water significantly, but does not fully get rid of the risk of waterborne pathogens (Clasen et al., 2008) [26]. Therefore, water disinfection needs to combine with good hygiene practices to prevent pathogens, thereby preventing water-borne diseases (Machdar et al., 2013) [24].

In terms of the issue of feeling on water quality with the current supply water, the majority of households (88.8 %) reported that the groundwater may be accepted, while about 11.2 % of households do

not ensure that groundwater is safe and sensory evaluation of water quality is unsafe (e.g. smell or color). Among the families who rated water quality as unsafe, they reported that water quality problems often occur in the dry season, the water reserves are not enough for daily purposes. This is because the water of the dug/open wells is usually from 12 - 25 m in - depth and in the rainy season, the water recedes, so the sandy soil at the bottom may cause high turbidity or the contaminated water from runoff could enter wells.

3.2. Current environmental sanitation and the practices

Table 4. The survey results of environmental sanitation

Content	Response	No. of respondents (n)	Frequency (%)
Does the household have a toilet?	Yes	165	97.6
	No	4	2.4
What kind of toilet?	Septic tank	15	8.9
	Semi-septic tank	115	68.0
	Dry latrine	35	20.7
	No	4	2.4
	Total	169	100
How far does the distance from toilets to water sources?	1 - 5 m	43	25.4
	5 - 15 m	72	42.6
	>15 m	50	29.6
	No	4	2.4
	Total	165	100
Does the household have a barn?	Yes	**67**	39.6
	No	102	60.4
What is the distance from barns to water sources?	1 - 5 m	17	10.1
	5 - 15 m	27	16.0
	>15 m	23	13.6
	No	102	60.4
	Total	67	100
Does the household have livestock?	Yes	91	53.8
	No	78	46.2
	Total	169	100
How to collect and treat household waste?	Burning	62	36.7
	Composting	4	2.4
	Dumping waste	7	4.1
	Environmental company	96	56.8
	Total	169	100

In general, environmental sanitation and surrounding factors such as the position of the water source, the distance from the water sources to the toilet or the barns, fertilizing activities, or the application of pesticides in agricultural households could have a significant impact on water quality. Table 4 shows the survey results of environmental sanitation of the peri-urban areas in Pleiku city. Regarding the current status of using toilets, 165 out of 169 surveyed

households had toilets, only 4 households (2.4 %) did not have one. Open defecation increases the risk of infectious or water - borne diseases (Ravindra et al., 2019) [23]. When considering the types of toilets, 15 households (8.9 %) used a septic tank, 115 households (68.0 %) used the semi-septic tank and 35 households (20.7 %) had dry latrines. Since most families use dug well water/ groundwater, it is important to consider the distance from the toilet to these water sources (Kimani-Murage and Ngindu, 2007) [27]. Notably, 25.4 % of households (n = 43) had toilets within a radius of 1 - 5 m, of which 9 households used dry latrines, which may affect water quality (Shivendra and Ramaraju, 2015) [28]. The frequency of households with a distance of 5 - 15 m is 42.6 % (n =72), the figure for the distance >15 m is 29.6 % (n = 50).

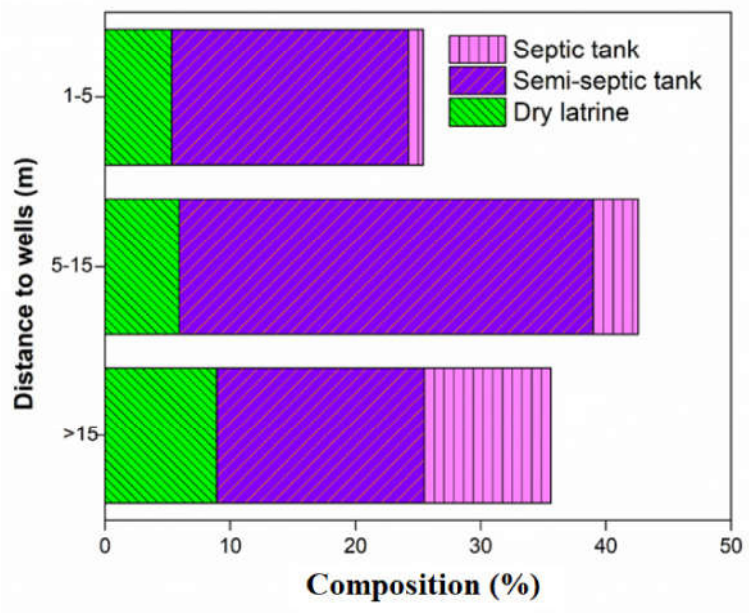

Figure 6: The types of toilet and the distance to wells

Household farming activities could also affect water availability, especially barns (Goss et al., 1998) [29]. The results demonstrated that 39.6 % (n = 67) households had barns, of which 19 households raise buffaloes, cows and goats with one or more and 28 households raise pigs with one or more. The households had barns for raising buffaloes, cows, goats, or pigs, it is possible to generate waste, wastewater discharged directly into the surrounding area without treatment. About 27 households (16 %) had a 1 - 5 m distance from these barns to water sources (Tab. 4). Therefore, it is necessary to manage waste and wastewater generated from these barns due to a high-risk level of introducing contaminants to water sources.

3.3. Practicing measures in improving the quality of water supply and environmental sanitation

According to Decision No. 1566/QD-TTg of the Prime Minister on approving the national program to ensure safe water supply in the 2016 - 2025 period. In which, the common goal of clean water is that by 2020, the proportion of the population supplied with clean and hygienic water will reach 90 - 95 % and reduce 20 % of diarrhea - related to drinking water; By

2025, 95 - 100 % of the population will be provided with clean water and 30 % reduction of diarrhea related to water. To achieve this goal, it is necessary to implement water supply and sanitation practices to limit the spread and risk of water - borne diseases (Trevett et al., 2005) [30]. There are many measures to improve water quality during the process of water supply system such as implementing water safety plans (WHO, 2012) [31], maintaining and upgrading water supply systems (WHO, 2005) [32], monitoring water quality (Schmoll, 2006) [9], communicating to raise public awareness (Anh et al., 2019) [33]. In addition, using water sparingly and the replacement sources of water (such as rainwater or tap water) should be considered to apply in communities. Especially, proposing the priority solutions to improve the quality of supply water and human health protection are shown in Table 5.

Table 5. Proposing the priority solutions

No.	Solutions	Priority	Period time	Villages
1	Training on water and sanitation	1	Annual	Bien Ho, Ia Kenh, Chu A
2	Upgrading pipeline and storage	4	Annual	Ia Kenh, Chu A
3	Monitoring water quality	2	Annual	Ia Kenh, Chu A
4	Improving domestic hygiene condition	3	Annual	Bien Ho, Ia Kenh, Chu A
5	Applying water and sanitation safety plan	5	One year	Bien Ho

These solutions should be considered when applying to the water supply and sanitation to protect public health and reduce water - borne diseases. Classifying the participation levels of stakeholders is essential in the implementation of solutions related to the domestic water supply system (Anh et al., 2019) [17] and the stakeholders should coordinate effectively, which helps achieve the goal of clean water supply. The stakeholders who are actively involved include Government, Local Authority, Department of Agriculture and Rural Development, Department of Natural Resources and Environment, the Department of Health. They are considered as co - working stakeholders and involved actively in the policy-making process. Expectant stakeholders (co - thinking) are experts, media should be consulted in order to gain useful information and opinions from various sources, which help improve the efficiency of the water supply system. Furthermore, the appropriate level of involvement for communities is the latent stakeholders (co - knowing) [17].

4. Conclusions

The study assessed the current status of the domestic supply of water and measures in improving water quality in the peri - urban areas of Pleiku city. The results showed that households are quite satisfied with the current supply of water sources (groundwater), especially in the rainy season. However, when considering sanitation practices, research indicated that the current state of toilets and barns in some households are located at a close distance from domestic water sources, which may negatively impact the long term. It is necessary for improving domestic hygiene conditions in households. Regarding the form of water storage, some households still use plastic materials, which can also increase the possibility of contamination in a long-term period and do not regularly clean the storage tank. Therefore, cleaning and upgrading pipelines and storage should

be implemented regularly. In addition, the related agencies should organise the program of training water and sanitation to communities. The level of participation of stakeholders in applying solutions to improve domestic supply water and environmental sanitation is rated. This helps managers and policymakers to clarify the level of stakeholder engagement and to adjust policies and solutions in the future. Finally, the authorities should consider applying water and sanitation safety plans for communities, which help maintain water quality and prevent disease.

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