Determination of Arsenic and Chemical Pollution of GroundWater at BrajiengJalern Souk District of Champasak Province

SAIYALARD SengChan[1], PHIMPHANTHAVONG Kanit[2], LATSAPHONH Thongphanh[3], LASAJACK ThipphaJon[4] and PHOMSOUPHA Souksamlan[5]

Abstract

This research determined the concentration of Arsenic and chemical pollution of ground water at BraJiengJalern Souk District, Champasak Province.In thisarea there is no local piped “town water”supply in use, and almost all the people rely on ground water. Unfortunately, farmers use insecticides and herbicides containing compounds of Arsenic (As) leading to the contamination of Arsenic(As)compounds in the groundwater of this area.Groundwater samples from 6 stations (HouyHair, UdomSouk, MoungKhai, HouSiew, HouyPheun, and NongKhok villages of BrajiengJalernSouk District, Champasak Province 2017) were collected and analyzed for pH, Electrical conductivity ,temperature, Sulfate (SO_4^{2-}), Sulfide (S^{2-}), Iron (Fe^{2+}), Manganese (Mn^{2+}), free Nitrogen Ammonia ($N\text{-}NH_3$), and Arsenic (As). The experimental results showed that the pH values of water samples from each station were 4.74 - 6.42 lower than the standard range of 6.5 - 9.5). Electrical conductivity values of the samples from 4 stations were found in the range of 24.6 - 287 µS/cm, except that from HouyPheun village which was 1077 µS/cm beyond the standard (value of<1.000 µS/cm). (SO_4^{2-}).Concentration of water samples from each station were 2 - 40 mg/L, lower than the standard value of <200 - 250 mg/L). Surprisingly, the concentration of (S^{2-})of water samples were 17 - 24 mg/L, much higher than the standard value of 0.1 mg/L. The Fe^{2+} concentration of the sample water was 0.18 - 0.29mg/L,but that of the water sample from HouyPheun village was 2.38 mg/L, slightly over the standard value of 0.3 - 1 mg/L. Considering the presence of Mn^{2+} ions, only water from MoungKhai village was found at a concentration of 0.24 mg/l which was under Mn^{2+} (the standard value 0.5 mg/L).The As concentration in all collected water samples were 0.001- 0.002 mg/L. The free Nitrogen Ammonia ($N\text{-}NH_3$) content of 6 samples was0.15 - 0.53 mg/l, lower than the standard value of 0.5- 1.5 mg/L. It could be concluded that overall the quality of ground water of all 6 stations was quite poor when compared to the standard value for the quality of ground water used for household consumption.Villagers need to get advice on how to boil and filter water before using it in the home. These areas need to access and use the piped water supply nearly.

[1]ພາກວິຊາເຄມີສາດ ຄະນະວິທະຍາສາດ ທຳມະຊາດ ມະຫາວິທະຍາໄລ ຈຳປາສັກ
Department of chemistry, Faculty of Science at Champasak University
Corresponding author .Email: Ssaiyalard@yahoo.com
[2]ພາກວິຊາເຄມີສາດ ຄະນະວິທະຍາສາດ ທຳມະຊາດ ມະຫາວິທະຍາໄລ ຈຳປາສັກ
Department of chemistry, Faculty of Science at Champasak University
[3]ພາກວິຊາເຄມີສາດ ຄະນະວິທະຍາສາດ ທຳມະຊາດ ມະຫາວິທະຍາໄລ ຈຳປາສັກ
Department of chemistry, Faculty of Science at Champasak University
[4]ພາກວິຊາເຄມີສາດ ຄະນະວິທະຍາສາດ ທຳມະຊາດ ມະຫາວິທະຍາໄລ ຈຳປາສັກ
Department of chemistry, Faculty of Science at Champasak University
[5]ພາກວິຊາເຄມີສາດ ຄະນະວິທະຍາສາດ ທຳມະຊາດ ມະຫາວິທະຍາໄລ ຈຳປາສັກ
Department of chemistry, Faculty of Science at Champasak University

Keywords: Arsenic, and Chemical Pollutants of Ground water

ບົດຄັດຫຍໍ້

ງານວິໄຈນີ້ໄດ້ກຳນົດຄວາມເຂັ້ມຂຸ້ນຂອງປະລິມານອາເຊນິກ (As) ແລະມົນລະພິດທາງເຄມີຂອງນ້ຳບາດານໃນເຂດພື້ນທີ່ເມືອງບາຈຽງຈະເລີນສຸກແຂວງຈຳປາສັກ ,ໃນເຂດພື້ນທີ່ດັ່ງກ່າວຍັງບໍ່ທັນມີນ້ຳປະປານຳໃຊ້ແລະ ເກືອບທຸກຄົນໃນເຂດພື້ນທີ່ເຫຼົ່ານີ້ໄດ້ນຳໃຊ້ນ້ຳບາດານເຂົ້າໃນການບໍລິໂພກ- ອຸປະໂພກໃນຄົວເຮືອນ ແລະກະສິກຳເຊິ່ງເຂດດັ່ງໄດ້ນຳໃຊ້ຢາຂ້າແມງໄມ້ ແລະ ຢາຂ້າຫຍ້າທີ່ມີສ່ວນປະສົມຂອງທາດອາເຊນິກ (As) ທີ່ປົນເປື້ອນໃນນ້ຳບາດານ ,ໃນການສຶກສາຄັ້ງນີ້ ແມ່ນໄດ້ສຸ່ມເກັບຕົວຢ່າງຢູ່ 6 ບ້ານ (ບ .ຫ້ວຍແຮ ,ບ .ອຸດົມສຸກ ,ບ .ມ່ວງໄຂ່ ,ບ .ຫົວສ້ຽວ ,ບ .ຫ້ວຍພື້ນ ແລະ ບ .ໜອງກ໊ອກ ເຂດເມືອງບາຈຽງຈະເລີນສຸກ ແຂວງຈຳປາສັກ ປີ2017) ໄດ້ສຸ່ມເກັບຕົວຢ່າງ ແລະ ທຳການວິເຄາະຫາພາລາມິເຕີທີ່ຕ້ອງການເຊັ່ນ :ອຸນຫະພູມ(Temperature) ນຳໃຊ້ບາຫຼອດວັດແທກໄດ້ໂດຍກົງ Thermometer ,ພີເອຊ (pH) ນຳໃຊ້ເຄື່ອງ pH Meter, ສະພາບຊັກນຳໄຟຟ້າ (Conductivity) ນຳໃຊ້ເຄື່ອງ Conductivity Meter, [ຊັລເຟດ (SO_4^{2-}), ຊັລໄຟດ໌) S^{2-}(, ເຫຼັກເຟີຣັສ) Fe^{2+}), ມັງກາເນດສ໌) Mn^{2+} (ແລະ ແອມໂມເນຍໄນໂຕເຈນ ($N\text{-}NH_3$) ແມ່ນນຳໃຊ້ເຄື່ອງPhotometer MD600 ວິໄຈ] ແລະ ອາເຊນິກ (As) ນຳໃຊ້ວິທີ APHA,AWWA,WEF.(2012), 3030E ວິໄຈ ,ຜົນການວິໄຈໃນແຕ່ລະຈຸດມີດັ່ງນີ້ :ຄ່າພີເອຊ (pH) ແມ່ນຢູ່ໃນຊ້ອງ 4.74 - 6.42 ເຊິ່ງຕ່ຳກວ່າຄ່າມາດຕະຖານ(ຄ່ມາດຕະຖານ 6.5- 6.9), ສະພາບຊັກນຳໄຟຟ້າ (Conductivity) ແມ່ນຢູ່ໃນຊ້ອງ16.3-287 µs/cm ແຕ່ຍົກເວັ້ນບ້ານຫ້ວຍພືນແມ່ນມີຄ່າສູງກວ່າຄ່າມາດຕະຖານ 1077 µs/cm (ຄ່າມາດຕະຖານ<10000 µs/cm), ຄ່າຊັລເຟດ (SO_4^{2-}) ແຕ່ລະຈຸດແມ່ນຢູ່ໃນຊ້ອງ 2-40 mg/L ເຊິ່ງຕ່ຳກວ່າຄ່າມາດຕະຖານ(ຄ່າມາດຕະຖານ<200-250 mg/L), ເປັນເລື່ອງທີ່ໜ້າສົນໃຈທີ່ປະລິມານຂອງຊັລໄຟດ໌ S^{2-} (ມີຄ່າສູງກວ່າຄ່າມາດຕະຖານ 17-24 mg/L (ຄ່າມາດຕະຖານ 0.1 mg/L), ຄ່າເຫຼັກເຟີຣັສ) Fe^{2+}) ແມ່ນຢູ່ໃນຊ້ອງ 0.18-0.29 mg/Lແຕ່ຄ່າຂອງເຫຼັກເຟີຣັສຢູ່ບ້ານຫ້ວຍພືນມີຄ່າສູງກວ່າໝູ່ 2.38 mg/L (ຄ່າມາດຕະຖານ 0.3-1 mg/L), ຄ່າຂອງມັງກາເນດສ໌) Mn^{2+} (ແມ່ນສູງກວ່າຄ່າມາດຕະຖານແຕ່ຍົກເວັ້ນບ້ານມ່ວງໄຂ່ແມ່ນຕ່ຳກວ່າມາດຕະຖານ0.24 mg/L (ຄ່າມາດຕະຖານ0.5 mg/L), ຄ່າຂອງອາເຊນິກ (As) ແມ່ນຢູ່ໃນຊ້ອງ 0.001-0.002 mg/L (ຄ່າມາດຕະຖານ 0.01-0.05 mg/L) ແລະ ຄ່າຂອງໂມເນຍໄນໂຕເຈນ ($N\text{-}NH_3$) ທັງ 06 ຈຸດແມ່ນໃນຊ້ອງ 0.15-0.53 mg/L ເຫັນວ່າຕ່ຳກວ່າມາດຕະຖານ(ຄ່າມາດຕະຖານ 0.5-1.5 mg/L) ເຊິ່ງສາມາດສະຫຼຸບໄດ້ໂດຍລວມວ່າ :ຄຸນນະພາບຂອງນ້ຳບາດານທັງ 06 ຈຸດທີ່ໄດ້ກວ່ມາຂ້າງເທິງນັ້ນແມ່ນຂ້ອນຂ້າງຊຸບໂຊມລົງເມື່ອງປຽບທຽບກັບຄ່າມາດຕະຖານສິ່ງແວດລ້ອມແຫ່ງຊາດຂອງນ້ຳໃຕ້ດິນທີ່ໃຊ້ສຳລັບບໍລິໂພກໃນຄົວເຮືອນ ,ສະນັ້ນຊາວບ້ານເຂດດັ່ງກ່າວຄວນຈະໄດ້ຮັບຄຳແນະນຳກ່ອນຈະນຳເອົານ້ຳບາດານຂຶ້ນມາໃຊ້ເຊັ່ນ :ຄວນຈະຕົ້ມ ,ຕອງແລະເຂດພື້ນທີ່ເຫຼົ່ານີ້ຄວນຈະເຂົ້າເຖິງແຫຼ່ງນ້ຳປະປາ.

ຄຳສຳຄັນ: ອາເຊນິກ ແລະ ມົນລະພິດທາງນ້ຳຂອງນ້ຳບາດານ

Introduction

BrajiengJalern Souk District in Champasak Province has an area of 78474 square kilometers on a plateau. There are a total 47 villages, divided into 5 groups. The population

numbers 57785 and there are 9079 roofs. Ground water in the area, around 7800 liters, has a depth of about 25- 40 meters. In these villages most people are still using ground water and well waters for human consumption and agriculture. The area is contaminated by plant pesticides and herbicides from Yunggaosu Laos-Vietnam Company, an Association of Vietnamese investment in the region. This rate of contamination is higher than the accepted risk of accumulated poisons in ground water. Arsenic is a heavy metal found in many wells and ground water, and in wetlands because of flooding. According to a geology map from the university of UNICEP,2014, in three provinces of Laos - BolikhamXai, ChamPasack and Sekong Province – the volume of arsenic in underground water outweighs the standard (STD value 10μg / L). The volume more or less depends on the soil (geology university). Arsenic is detrimental to public health and particularly affects the health of humans. The amount of arsenic in ground water was studied in the following areas: Houy Hair, UdomSouk, MoungKhai, HouyPheun, Nongsiem and NongKhok villages of BrajiengJalern Souk District Champasak Province. These villages were selected as people in these areas used ground water for human consumption and used pesticides in crop farming resulting in ground water in the area accumulating arsenic compounds which caused water quality to decay. In the last investigation two southern provinces using high volumes of arsenic proved to have clean underground water supplies as the check did not identify arsenic such as: the volume of iron (Fe^{2+}) and electrons (reducing process) to cause As (III) and As (V). This suggests that combined ground water and underground water is seeping from the soilbecause water from underground reservoirs of various depths may flow from one reservoir to another reservoir. It may also be due to the system of earth's water circulation which refers to the chemicals moving because of the changing conditions of water on Earth such as: the molecules of water change from a liquid into a solid state from a solid or gas into liquid state. Underground water becomes water in the soil, or rock. Groundwater originating from the water in the atmosphere or surface water usually has improved physical and biological conditions such as: transparency, absence of turbidity or crystallization and bacteria; the chemical composition or quality of groundwater, passing through soil and rock, is uncertain, and may have mineral and chemical contaminants in amounts greater than water surface. The character of ground water may be typed in two ways.The two types of floor water aquifer - Soil or a rock floor saturated with water, and trapping a considerable volume of water- are unconfined and confined. Unconfined Aquifers have a layer of shallow underground water. This water level changes each season. In the dry season the water level is deep, but in the wet season the level is shallow. Confined Aquifers have a floor deep under the ground, a floor of soil or water seeping through the rock cover above, resulting in greater water pressure. Contamination may be dissolved minerals from permeable rock salt or rusty Iron. The floor water of confined aquifers does not change much with seasons but floors may alternate more.

There are three types of underground water sources: well water, ground water, and hot fountain water, but only two types are consumed by humans:

Well water: the sources underground water is digging deep few. It is often not depth at the top level, can used tools such as: hoe or digger can dig. Basin well water like to by soil brick or Tank used by cement to protect landslide quality of well water like will not differences quality of sources soil by near area, but may be turbidity or crystalline.

- Ground water: ground water is sourced very deep underground when compared with well water. Machinery is used to access it. Some places have found that the ground water sourced is a small basin which pumps strongly at first but then the water dries up.

Arsenic was discovered 1733 years ago by AlbertusMagners, The compound of Arsenic with Sulfate is yellow. The chemical symbol of Arsenic is (As). It has 33 atoms and a mass of 74,9216 g/mol, Arsenic is classified VA, 4 cycles, and an electro arrangement of As: [Ar] $4s^2 4p^3$. Arsenic is semi-metallic and can react with both metals and nonmetals. When burned, the flame will turn blue; the white flame of Arsenic oxide As_2O_3 smells like garlic. Arsenic has no solubility. It has no reaction with Sulfuric acid (H_2SO_4),or hydrochloric acid (HCl) when cool, but when heated, its reaction with Nitric acid (HNO_3) or Sulfuric acid (H_2SO_4) produces Arsenous or Arsenic acid. When a yellow powder, Arsenic has a specific gravity of 1.79 and transforms easily into metallic Arsenic when amorphous black Arsenic with a specific gravity of 3.7 is heated and the temperature is raised to27°C :

$$2\,As + 3\,H_2SO_4 \xrightarrow{(heat)} As_2(SO_4)_3 + 3\,H_2$$

$$As + 3\,HNO_3 \xrightarrow{(heat)} As(NO_3)_3 + 3/_2\,H_2$$

Arsenic is a solid with a density of 5.22 g/cm^3, a melting point of 817°C and presents as 3 types. Black Arsenic from the amorphous Arsine (AsH_3) will divide into pieces when heated to high temperatures. If arsenic gas is cooled, its yellow evaporation will quickly turn to metal. Gray Arsenic results from laboratory stabilization of a metal withOxygen in the gases converted to a gray or black color. Metallic Arsenic maintains its characteristics the longest under normal conditions. There are some advantages and disadvantages of Arsenic as an element or compound. Arsenic has been used to extract minerals and as a pesticide. However, Arsenic in element or compound form is toxic to humans if it is ingested or inhaled.100 mg of Arsenic will kill but Arsenic can accumulate in the body over a sustained period to cause harm, for example Arsenic found in water, especially ground water containing arsenic from factory dust or pesticides, can cause cancer. Arsenic occurs naturally from the erosion of rocks and minerals containing such compounds as: Arsenopyrite (FeAsS). Arsenic might also be located in the environment, especially in soil (value 0.1 – 40 mg/kg) and natural water sources such as: sea, rivers and well water.

Industrial or agricultural use of Arsenic has resulted in increased environmental hazards. Such applications include: mining, metal smelting, fertilizers and pesticide. Arsenic is also used in the preservative of wood and sometimes mixed in animal feed. It also has medicinal applications in the treatment of human and animal diseases.

There are 2 type of arsenic such as:

- Organic Arsenic : Monomethyl Arsonite (MMA (III)), Arsenobetaine (AsB), Monomethyl arsonate [MMA(V)], Dimethylarsonnite [DMA(III)], Dimethyl Arsonate [TM(V)], Arsenocholine (AsCl), Arsenosugar (III)]
- Inorganic Arsenic : [Arsenite [As(III)], Arsenate [As(V), elemental Arsenic [As(O)], Arsene AsH_3[As(-III)] usually Arsenic found in water is organic as inorganic Arsenic is more toxic than the Arsenic pure (As) inorganic Arsenic mostly found in contaminated dust and those areas which have used pesticides. Arsenic has environmental effects such as: Arsenic metalloid commonly occurring naturally, Arsenic and its compounds can be moved through the distribution of dissolved gases when the Arsenic reaction with Oxygen formsArsenate As(III) which can be dissolved in ground water or surface water, but these process will be slow. Arsenic found in the environment- soil, water, sediment and sea- will be altered because of natural

processes or human activity and will continue to seep through rock, minerals and soil into water and then into the food chain.

Material

The principle of this research is choosing the station areas that are similar in parameter with a current area from a first source. The parameter consists of samples and instruments- Thermometer, pH Meter (A), Conductivity Meter (B) and Photo Meter MD 600 (C),and Atomic Absorption Spectrophotometer (AAS) (D)

(A)

(B)

(C)

(D)

Methodology

In this section, we describe the methodology used to determine the Arsenic and chemical pollution of ground water'. Initially Arsenic and chemical pollution of ground water were studied and these experiments were analyzed by Thermometer for temperature (T), pH meter for pH (power of hydrogen), Conductivity meter for conductivity (Conduct) , Photo MD 600 for and Arsenic (As) by APHA,AWWA,WEF (2012),3030 E. The methodology is shown in Figure 1.

Literature Review

A study of a literature review indicated Arsenic and chemical pollution of ground water occurs mostly in January to March 2016

Figure 1: Diagram of operation

Results and Discussion

Comparative results are tabled below:

Parameter	Houy Hair	UdomSouk	MoungKhai	HouyPheun	Nongsiem	NongKhok	STD
T(°C)	28.9	29,3	28.8	30.5	30.5	29.3	25-30
pH	5.14	4.74	4.93	5.54	5.27	6.42	6.5-9.5
Conductivity (μS/cm)	24.6	16.3	38.8	1077	61.1	287	<1000
SO_4^{2-} (mg/L)	9	7	5	40	2	12	200-250
S^{2-}(mg/L)	24	18	17	27	20	22	0.1
Fe^{2+} (mg/L)	0.18	0.24	0.03	2.38	0.29	0.19	0.3-1
Mn^{2+} (mg/L)	0.62	0.92	0.21	1.21	0.82	0.65	0.5
Arsenic (mg/L)	0.001	0.002	0.001	0.001	0.001	0.002	0.01-0.05
$N\text{-}NH_3$	0.	0.15	0.21	0.53	0.45	0.41	0.5-1.5

(mg/L)	31						

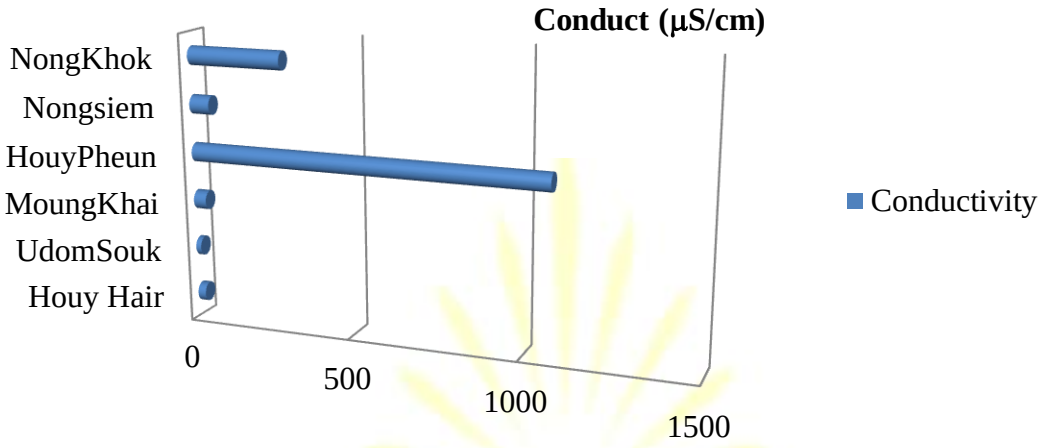

Figure 2: Electrical conductivity values of water sample from 6 sampling stations.

Conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water. These *conductive* ions come from Alkali and Alkaline-earth metal. Temperature is used as a measure because inorganic compounds release good electrolyte because it can be decomposed in water, but organic compoundsdo not decompose in the water so there is no conductivity. The parameter's value is standard.

.

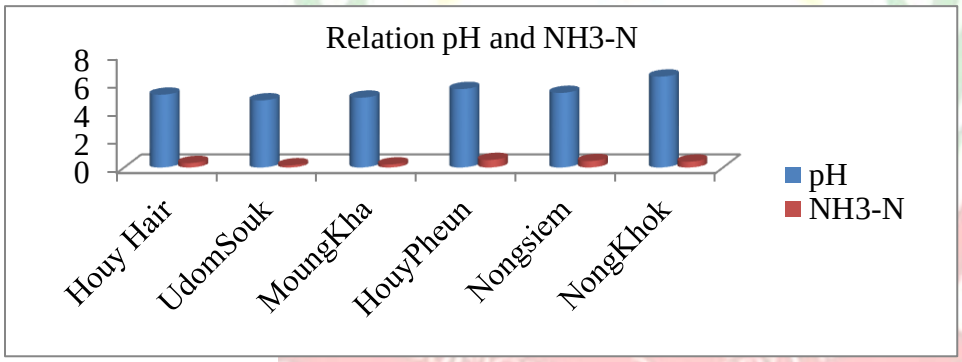

Figure 3: Comparison between pH and NH_3-N

In the relationship between pH and NH_3-N the theoretical pH of ground water has a value lower than 7 (at range 5-6), but pH in the studies found in UdomSouk and MoungKhai villages are low because of the low free ammonia nitrogen result in the ground water. Because free ammonia nitrogen comes from digestible or rotten plants and organic Nitrogen from animals, the water has free ammonia nitrogen from mixing with wastewater and may have germs (Nitrozomas); free ammonia nitrogen as found in nature has low contamination when compared in areas of wastewater

.

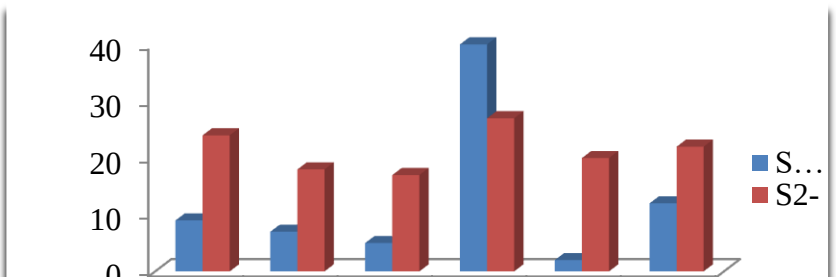

Figure 4: Comparison between Sulfate (SO_4^{2-}) and Sulfide (S^{2-})

The relationship between Sulfate (SO_4^{2-}) in the form of ion of Alkaline-earth Metal in water as: $MgSO_4$,$CaSO_4$, and S^{2-} in form H_2S dissolved in water, the theory is reversed (value of SO_4^{2-} high) but low Sulfide (S^{2-}) and different, becausethe value reversal is caused by more oxygen dissolved in water or oxygenused by bacteria in water.

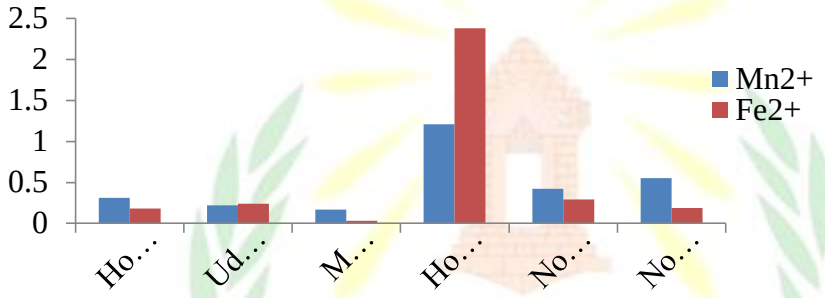

Figure 5: Compression of Manganese (Mn^{2+}) and Iron (Fe^{2+}) concentrationinwatersamples from 6 sampling stations

The areas of 6 studied stations found the value of Mn^{2+} increased at the estuary where accumulated decrystallization occurred. Normally ground water has the value Mn^{2+} at the estuary over that of surface land, but only Moungkhai village is standard. The value Fe^{2+} is lower than the standard of the set environment of 5 mg/l, but HouyPheun village was over standard 2.38 mg/l.

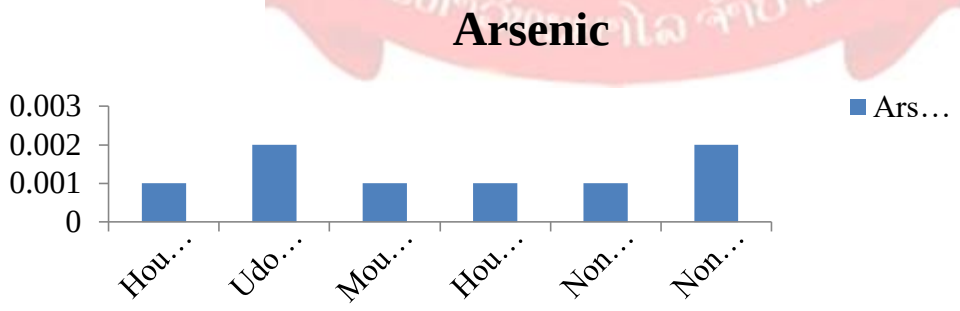

Figure 6: Arsenic values of water sample from 6 sampling stations.

The standard for Arsenic in ground water for consumption and consumers is 0.01-0,05 mg/Lin the areas studied so the values of Arsenic is the villages are lower than standard.

Conclusion and recommendation

The research compared findings with the national standard environment 2734/PM00WREdate 07 DEC 2009 and found that: the pH of water was lower than standard, temperature ,conductivity, free ammonia and sulfate were at standard , but sulfide was over the standard , Manganese (Mn^{2+}) value increased atthe estuary because of accumulated crystal. Normally ground water has a value of Manganese (Mn^{2+})when atan estuary as surface water. The value of Iron Fe^{2+} (II) at all 6 stations was lower than standard when compared with environment national set 1mg/l , but the ground water of HouyPheun village was over the standard 2.38 mg/l . Arsenic in ground water for consumption and consumers is standard 0.01 - 0.005 mg/l. In this research we can summarize: these 6 stations are still at the standard level , but had some parameters and some areas that are over standard, such as Sulfide at every station 17-24 mg/l,) 2.38 mg/l of Iron Fe^{2+} (II) werefound at HouyPheun village and the values of Manganese (Mn^{2+}) 0.62, 0.65, 0.82, 0.92 and 1.21mg/l werefound at Houy Hair, NongKhok, Nongsiem, UdomSouk and HouyPheun village because these areas are agricultural and have used chemistry fertilizer, pesticides and compounds of natural fertilizer. Pollution also depends on soil structure and many mines have contaminated the surface ground. A recommendation resulting from the findings of this research is that people in the nominated areas obtain clean drinking water because this research identifies that some parameters have values higher than standard such as Sulfide at every station, Iron Fe^{2+} (II) atHouyPheun village, Manganese (Mn^{2+}) at Houy Hair, NongKhok, Nongsiem, UdomSouk and HouyPheun villages. This means that all drinking water must always be boiled and filtered, and the villagers must be made aware of this so that they will seek out a clean water supply.

Acknowledgement

The authors thank the Groundwater Research Team, the Laboratory of Champasak University for the facilities provided for this Research, and the Asian Development Bank (ADB) Project for a Scholarship award.

References

Munsin, M. (2003). “Quality Analyze Control Water”, Thailand, Department Engineering Environment, Faculty of nature science ,Julalongkone University, Asian.

Vaphaserd, HartSaJaLy, and KingKeo, V.H.K, (2010). “ Determinationof quality ground water NongViengKham village ”Laos , Department Chemistry, Faculty of Nature Science , National University , Asian.

VingPhone, Bounthong, and Phonemany , V.B.Ph, (2011) “ The contamination of As in groundwater ,Savannakhet Province ” Laos, , Department Chemistry, Faculty of Nature Science , National University , Asian.

Khunthaly, Philavan, and Sengchan, Kh.Ph.S. (2011). “Collin’s Compare diagram for Alkalinity”, Laos, Department Chemistry, Faculty of Nature Science , National University , Asian.

Prime Minister’sOffice, P.M.O, (2009)“ Lao National Environment Standard ”, Laos National Environment minister division, Asian.