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การปนเปื้อนของโลหะหนักในดินจากสถานที่กำจัดขยะมูลฝอยและพื้นที่นาข้าวโดยรอบองค์การบริหารส่วนตำบลโคกสะอาด อำเภอฆ้องชัย จังหวัดกาฬสินธุ์

Heavy Metal Contamination in Soil at Waste Disposal Site and Surrounding Paddy Field Area in Khok Sa-At Subdistrict Administrative Organization, Khong Chai District, Kalasin Province

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งานวิจัยนี้มีวัตถุประสงค์เพื่อศึกษาคุณสมบัติของดินและปริมาณโลหะหนักในดิน ณ พื้นที่นาข้าวรอบสถานที่กำจัดขยะมูลฝอยองค์การบริหารส่วนตำบลโคกสะอาด อำเภอฆ้องชัย จังหวัดกาฬสินธุ์ ทำการเก็บตัวอย่างดินภายในพื้นที่ A, B และ C โดยพื้นที่ A ทำการเก็บตัวอย่างดินภายในสถานที่กำจัดขยะมูลฝอยที่ระยะห่างจากขอบแนวกำแพง 25 เมตร พื้นที่ B และ C ทำการเก็บตัวอย่างดินในพื้นที่นาข้าวรอบสถานที่กำจัดขยะมูลฝอยที่ระยะห่างจากขอบแนวกำแพง 2 เมตร และ 20 เมตร ตามลำดับ แต่ละพื้นที่ทำการเก็บตัวอย่างดิน จำนวน 6 จุด รวมทั้งหมด 18 จุด ในระหว่างเดือนสิงหาคม-เดือนพฤศจิกายน พ.ศ. 2561 ทำการตรวจวัดคุณสมบัติของดิน ได้แก่ ค่าความเป็นกรด-ด่าง ค่าการนำไฟฟ้า และปริมาณโลหะหนัก ได้แก่ ตะกั่ว แคดเมียม และทองแดง โดยใช้เทคนิคอะตอมมิกแอบซอร์บชั่นสเปกโทรโฟโตมิเตอร์ สถิติที่ใช้วิเคราะห์ข้อมูล ได้แก่ ค่าเฉลี่ย และส่วนเบี่ยงเบนมาตรฐาน ผลการศึกษาพบว่าพื้นที่ A, B และ C มีค่าเฉลี่ยความเป็นกรด-ด่างของดินอยู่ในช่วง 5.59±0.01 – 8.32±0.01, 4.05±0.01 – 8.46±0.00 และ 4.62±0.00 – 7.57±0.01 ตามลำดับ ค่าการนำไฟฟ้ามีค่าเฉลี่ยอยู่ในช่วง 12.72±0.04 – 195.47±0.06, 17.38±0.09 – 240.67±0.58 และ 17.81±0.20 – 190.23±0.06 ไมโครซีเมนต์ต่อเซนติเมตร ตามลำดับ ปริมาณโลหะหนักอยู่ในเกณฑ์มาตรฐานที่กรมควบคุมมลพิษกำหนดไว้ ยกเว้นปริมาณตะกั่วที่พบในพื้นที่ A ที่จุดเก็บตัวอย่าง 3A มีค่า 1,208.87±0.15 มิลลิกรัมต่อกิโลกรัม ซึ่งเกณฑ์มาตรฐานกำหนดไม่เกิน 400 มิลลิกรัมต่อกิโลกรัม

คำสำคัญ : โลหะหนัก ; สถานที่กำจัดขยะมูลฝอย ; พื้นที่นาข้าว

Abstract

The objective of this study was to examine the soil properties and heavy metals in the soil at the rice paddy fields surrounding the waste disposal site of Khok Sa-at Subdistrict Administrative Organization, Khong Chai District, Kalasin Province. The data collection involved collecting the soil samples from Spot A, B, and C. Spot A collected soil samples in the waste disposal site 25 meters away from the wall. Spot B and C collected soil samples in the rice fields surrounding the waste disposal site 2 meters and 20 meters away from the wall. Soil samples were collected from 6 spots in each area altogether 18 spots during August to November 2018. The soil properties were examined for pH, EC, and heavy metals by using Atomic Absorption Spectrophotometer Technique. The statistics for data analysis were mean and standard deviation. The results showed that Area A, B, and C showed pH at 5.59±0.01 – 8.32±0.01, 4.05±0.01 – 8.46±0.00, and 4.62±0.00 – 7.57±0.01 respectively. The EC mean was 12.72±0.04 – 195.47±0.06, 17.38±0.09 – 240.67±0.58, and 17.81±0.20 – 190.23±0.06 μS/cm. And, the heavy metals were in line with the standards prescribed by the Pollution Control Department except that of the lead in Spot A. The samples at Spot 3A detected lead at 1,208.87±0.15 mg/kg whereas the standard criteria prescribe not exceeding 400 mg/kg.

Keywords : heavy metal ; waste disposal site ; paddy fields

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Introduction

There are many types of waste generated in the community varied by the career activities. Electronic waste or e-waste evolved from the use of modern technologies to offer conveniences for humans in their daily routines that increase the amount of electronic waste such as mobile phones, tablets, computers, televisions, fans, refrigerators and washing machines (Kunacheva *et al.*, 2009; Cui *et al.*, 2008). When these electronic appliances are expired, they immediately and inevitably become e-waste. The e-waste is hazardous and containing heavy metals that directly affect human's health conditions. If the intake is relatively high, it will form acute poisoning effects. For example, lead causes seizure in children. However, if the intake is in small amount but consistently for a long time, it will accumulate in the body, damage the nervous system, and lead to anemia (Tiwari *et al.*, 2013; Nas *et al.*, 2018). After the electronic appliances containing toxic substances are disassembled, recycled, landfilled or burned, these toxins may leak into the environment and thus directly affect human health. Also, the recyclable e-wastes are normally sold to waste recycling shops and then mixed with other general waste.

The improper management of electronic product remains at present causes negative effects to the human health and environment such as burning electric wires to get copper for sale creates vapors of plastics and metals which is one of the causes of cancer. Melting circuit boards in order to extract lead and copper causes lead vapors spreading into the air and accumulating in soil and water. The use of acids to extract precious metals from circuit boards without proper waste water treatment causes contamination of waste water into the soil and water resources. Disassembling/removing refrigerators and air conditioning units without suction device to properly store refrigerant causes the refrigerant to escape into the atmosphere and destroy the ozone. Therefore, contamination and pollution resulting from recycling electronic waste begin from manufacturers to consumers and finally offer the risks on health and hygiene of people and the environment (Kunacheva *et al.*, 2009; Chan *et al.*, 2013; Chen *et al.*, 2011).

Currently, Khok Sa-at Subdistrict, Khong Chai District, Kalasin Province is the largest place for imported electronic waste in the country. More than 90% of the villagers work on disassembling electronic waste such as old electrical appliances, TVs, CPUs, and refrigerators, etc. The villagers begins by buying garbage from different places in order to sort, disassemble, melt and remove various components for sale such as steel, plastic or copper. Copper can be sold at the best price but the outer part of the cable must be removed to get only copper. The easiest way to get copper is to get the wires incinerated at the 23-rai waste disposal site of Khok Sa-at Subdistrict Administrative Organization which is a place where people discarded organic and inorganic waste. And, most of the waste being disposed here is solid waste generated from electronic remains accumulated for over 20 years (Office of the Chief Administrator of Khok Sa-at Subdistrict Administrative Organization, 2018). Consequently, the health of the villagers are at risk exposing to smoke or chemicals such as lead, cadmium, copper which are spread into the environment and they may affect the people around the waste disposal site, especially in areas where people perform agricultural activities such as farming and crop cultivation (Office of Natural Resources and Environmental Policy and Planning, 2017). Improper management of e-waste may result in contamination of heavy metal toxins into the rice field by accumulating in soil, water and various parts of plants which can circulate in the food chain of the people and are definitely harmful to people's health.

Therefore, the waste disposal site of Khok Sa-at Subdistrict Administrative Organization is likely contaminated by heavy metals and spread to the surrounding rice paddies. This research therefore aims to examine heavy metal contamination at the waste disposal site and the rice paddy soils surrounding the facility. This information can be used as the guidelines for people and related agencies to use in planning, prevention, control and solving options for problems of heavy metal contamination in the soil.

Methods

Khok Sa-at Subdistrict Administrative Organization is located at Ban Sa-at, Moo 2, Khok Sa-at Subdistrict, Khong Chai District, Kalasin Province, 10 kilometers away in the west of Kong Chai District, 30 kilometers away in the south of Kalasin province. It covers an area of approximately 35 square kilometers or approximately 21,893 rai. The basic geographical setting is fertile plains and suitable for agriculture. The natural water sources are Chi River and Gut Sai Jor Creek. About half of the agricultural land is irrigated by the Lam Pao Dam and the Chi River Water Supply by Electric Pumping Project. There are also small natural water sources scattered throughout the area for consumption and animal farming.

The study of soil properties and heavy metal contamination in the waste disposal site and the surrounding rice paddy fields at Ban Nong Bua, Moo 3 and Moo 11, Khok Sa-at Subdistrict, Khong Chai District, Kalasin Province covered a landfill area of approximately 23 rai. The soil collection spots within the waste disposal site were 18 spots. That is, 6 spots at a distance of 25 meters from the wall towards the inner area of the waste disposal site; 6 spots from the wall of the waste disposal site towards a distance of 2 meters into area of the surrounding rice fields; and 6 spots from the wall of the waste disposal site towards a distance of 20 meters into area of the surrounding rice fields. The soil samples were collected at a depth of 15 cm into the ground. The parameters under investigation are pH, electrical conductivity (EC) and heavy metals in soil e.g. lead (Pb), cadmium (Cd) and copper (Cu).

Figure 1 Soil Samples Collection Spots within Waste Disposal Site and the Surrounding Rice Paddy Fields

Source: https://www.google.co.th/intl/th/earth/

Notes :

A = The soil sample collection spots in the waste disposal site 25 meters away from the wall

B = The soil sample collection spots in the surrounding rice fields 2 meters away from the waste disposal site wall

C = The soil sample collection spots in the surrounding rice fields 20 meters away from the waste disposal site wall

Samples Collection Spot 1 refers to the area in the waste disposal site 25 meters away from the wall which is marked as spot 1A, and the other 2 spots in the rice fields i.e. 2 and 20 meters away from the waste disposal site wall towards the inner part of the rice fields which are marked as 1B and 1C respectively. Samples Collection Spot 1A refers to the area at the entrance of the waste disposal site. The soil conditions contain pieces of glass, plastic, foam, most of which are non-combustible waste. The setting is near the place where electronic waste is burnt such as wires, circuit boards, etc. as shown in Figure 2.

Figure 2 Conditions of the soil sample collection spot within the waste disposal site 25 meters away from the wall (1A)

Samples Collection Spot 2 refers to the area within the waste disposal site, 25 meters away from the wall, marked as Spot 2A. The other 2 spots are the areas in the rice fields located away from the waste disposal site wall 2 meters (2B) and 20 meters (2C) towards the inner areas of the rice fields. Spot 2A is the area near the waste cleaning well and there is the burning of e-waste around the well. The remains from burning left on the ground are pieces of glass, plastic, foam, wires, circuit boards, etc. The ground surface is black as a result of waste burning as shown in Figure 3.

Figure 3 Conditions of the soil sample collection spot within the waste disposal site 25 meters away from the wall (2A)

Samples Collection Spot 3 is located inside the waste disposal site 25 meters away from the wall marked at Spot 3A, and two soil sample collection spots in the rice fields are 2 meters (3B) and 20 meters (3C) away from the waste disposal site wall. The soil sample collection Spot 3A is posited near waste cleaning well surrounded by e-waste burning. The burning remains are pieces of glass, plastic, foam, wire, circuit board, and TV screen. The ground surface is black due to burning waste as shown in Figure 4.

Figure 4 Conditions of the soil sample collection spots in the waste disposal site 25 meters away from the wall (3A)

Samples Collection Spot 4 is located inside the waste disposal site 25 meters away from the wall marked as Spot 4A. The conditions of two soil collection spots in the rice fields 2 meters (4B) and 20 meters (4C) away from the wall. Spot 4A exists pieces of glass, plastic, foam, etc. The soil is black and adjacent to the area containing saline soil as shown in Figure 5.

Figure 5 Conditions of the soil sample collection spots in the waste disposal site 25 meters away from the wall (4A)

Samples Collection Spot 5 is posited inside the waste disposal site 25 meters away from the wall marked as Spot 5A. The other two soil sample collection spots are in the rice fields 2 meters (5B) and 20 meters (5C) away from the waste disposal site wall. Spot 5A exists extensive non-combustible e-waste e.g. glasses and TV screen and stains of burning waste. The ground surface is covered with pieces of glass, plastic, foam as shown in Figure 6.

Figure 6 Conditions of the soil sample collection spots in the waste disposal site 25 meters away from the wall (5A).

Samples Collection Spot 6 is located in the waste disposal site 25 meters away from the wall marked as Spot 6A. The other two soil collection spots are in the rice fields 2 meters (6B) and 20 meters (6C) away from the wall. Spot 6A is adjacent to the waste disposal site entrance. The ground is heavily covered with grass. Soil is black and covered with pieces of glass, TV screen, foam and plastic. There is slight stain of e-waste burning as shown in Figure 7.

Figure 7 Conditions of the soil sample collection spot in the waste disposal site 25 meters away from the wall (6A).

Results

The study of soil properties and the amount of heavy metals in the soil at the waste disposal site and in the rice paddy fields around the waste disposal site of Khok Sa-at Subdistrict Administrative Organization, Khong Chai District, Kalasin Province by the research team examined pH, electrical conductivity (EC), lead (Pb), cadmium (Cd) and copper (Cu) by collecting soil samples in the waste disposal site 25 meters from the wall and in the rice fields around the waste disposal site 2 meters and 20 meters away from the waste disposal site wall altogether 18 spots at a depth of 15 centimeters into the ground. The results were as follows:

pH

The pH of soil in the landfill site 25 meters away from the wall and the soil in the rice fields around the waste disposal site 2 meters and 20 meters away from the wall for a total of 18 spots were examined. The results were shown in Figure 8.

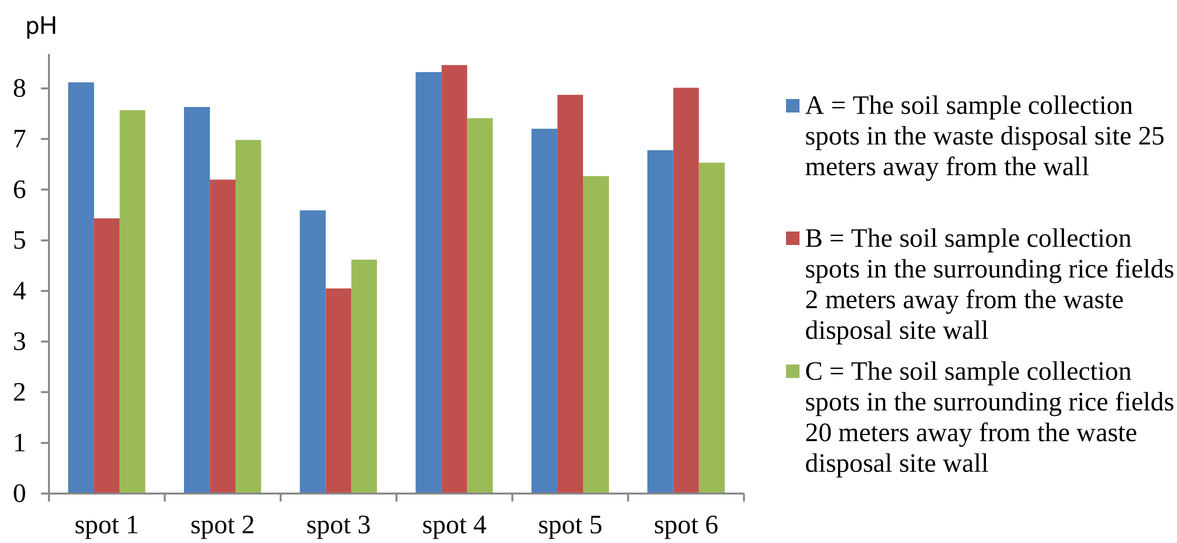

Figure 8 The pH of soil at each of the soil sample collection spots in the waste disposal site and in the rice fields around the waste disposal site of Khok Sa-at Subdistrict Administrative Organization

Figure 8 showed the amount of soil pH at the waste disposal site 25 meters away from the wall revealed pH mean at 5.59±0.01 – 8.32±0.01 and it could be seen that the soil pH in the waste disposal site ranged from acid to mild alkaline. And, the lowest pH was 5.59±0.01 at Spot 3A and the highest pH was 8.32±0.01 at Spot 4A. The rice paddy fields surrounding the waste disposal site 2 meters (B) away from the wall showed pH mean at 4.05±0.01 –

8.46±0.00. The lowest pH was 4.05±0.01 at Spot 3B and the highest pH was 8.46±0.00 at Spot 4B. The rice fields around the waste disposal site at 20 meters (C) away from the wall showed pH mean at 4.62±0.00 – 7.57±0.01. The lowest pH mean was 4.62±0.00 at Spot 3C and the highest pH mean was Spot 1C at 7.57±0.01. The pH mean across 18 spots was at 4.05±0.01 – 8.46±0.00.

Electrical Conductivity (EC)

The examination of electrical conductivity (EC) inside the waste disposal site 25 meters away from the wall and in the rice fields 2 and 20 meters away from the waste disposal wall in the total of 18 spots were reported as shown in Figure 9.

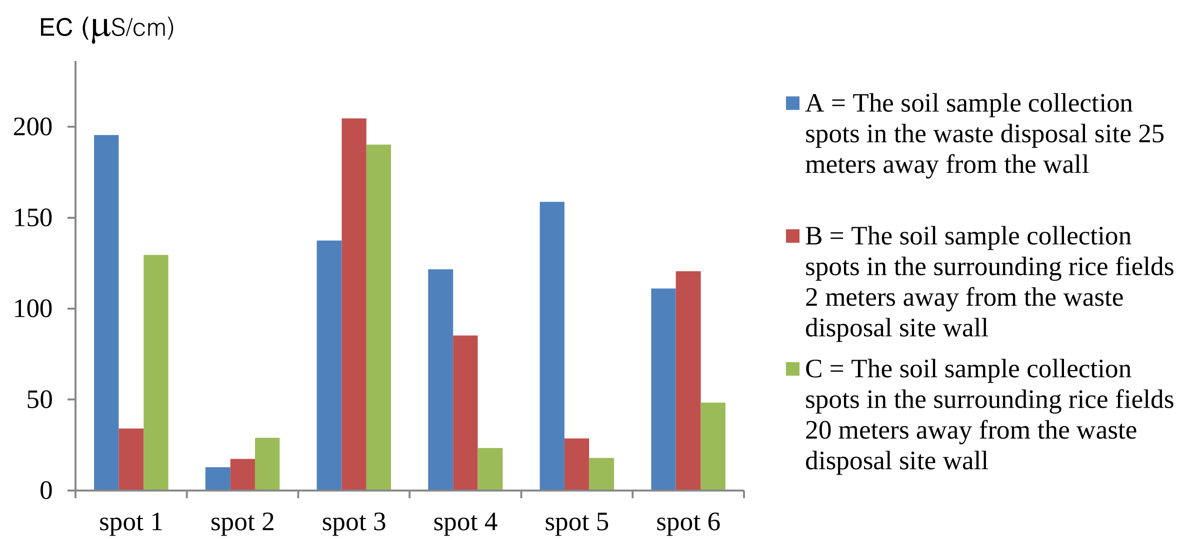

Figure 9 Electrical Conductivity (EC) at each of the soil sample collection spots inside the waste disposal site of Khok Sa-at Subdistrict Administrative Organization

From Figure 9, EC of the soil inside the waste disposal site 25 meters (A) away from the wall showed the mean at 12.72±0.04 – 195.47±0.06 μS/cm. The lowest EC mean was Spot 2A at 12.72±0.04 μS/cm and the highest EC mean was Spot 1A at 195.47±0.06 μS/cm. The EC mean in the rice fields surrounding the waste disposal site 2 meters (B) away from the wall showed EC mean at 17.38±0.09 – 240.67±0.58 μS/cm. The lowest EC mean was Spot 2B at 17.38±0.09 μS/cm and the highest EC mean was Spot 3B at 240.67±0.58 μS/per cm. The measurement of EC in the rice fields surrounding the waste disposal site 20 meters (C) away from the wall showed EC mean at

17.81±0.20 – 190.23±0.06 μS/cm. The lowest EC mean was Spot 5C at 17.81±0.20 μS/cm and the highest EC mean was Spot 3C at 190.23±0.06 μS/cm. The EC mean across 18 spots was at 12.72±0.04 – 240.67±0.58 μS/cm.

Amount of Lead in Soil

The examination of lead in the waste disposal site 25 meters away and in the rice fields surrounding the waste disposal site of Khok Sa-at Subdistrict Administrative Organization 2 meters and 20 meters away from the wall were reported in Figure 10.

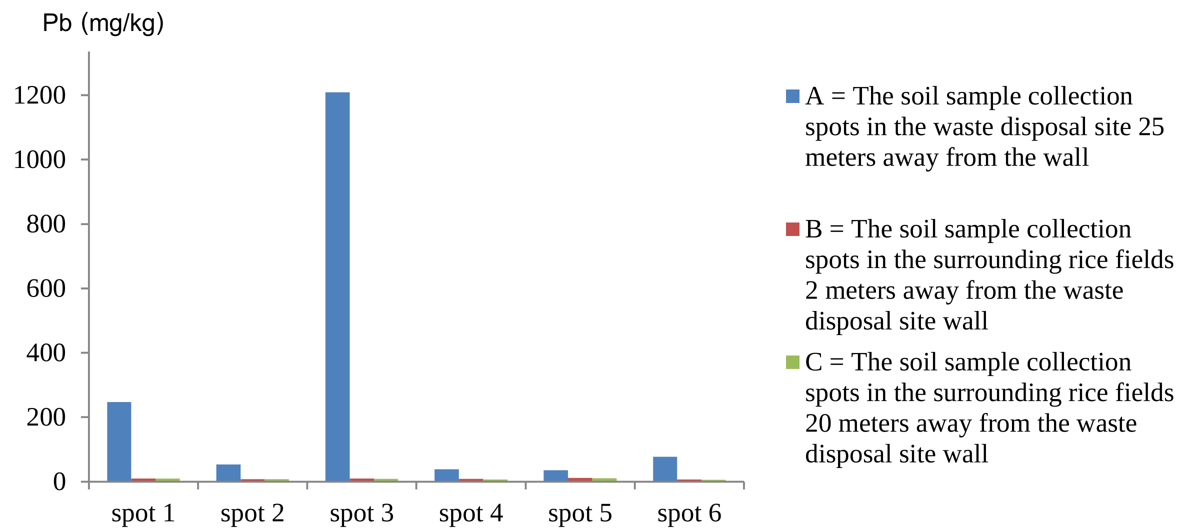

Figure 10 Mean of lead in soil samples from each of the spots in the waste disposal site and the rice fields surrounding the waste disposal site of Khok Sa-at Subdistrict Administrative Organization

From Figure 10, lead examination at the waste disposal site 25 meters (A) away indicated mean of lead at 35.53±0.17 – 1,208.87±0.15 mg/kg. The lowest mean of lead was Spot 5A at 35.53±0.17 mg/kg and the highest mean of lead was Spot 3A at 1,208.87±0.15 mg/kg. The rice fields surrounding the waste disposal site at 2 meters (B) away from the wall showed mean of lead at 6.53±0.15 – 11.70±0.10 mg/kg. The lowest mean of lead was Spot 6B at 6.53±0.15 mg/kg and the highest mean of lead was Spot 5B at 11.70±0.10 mg/kg. The examination of soil in the rice fields surrounding the waste disposal site 20 meters (C) away from the wall showed mean of lead at 6.03±0.15 – 10.40±0.10 mg/kg. The lowest mean of lead was Spot 6C at 6.03±0.15 mg/kg and the highest mean of lead was Spot 5C at 10.40±0.10 mg/kg. The lead (Pb) detected in the soil at the waste disposal site was examined against the standards of soil for agricultural use and residence prescribed by the Pollution Control Department indicated that Spot 3A showed lead at 1,208.87±0.15 mg/kg which exceeded the 400 mg/kg standards by the Pollution Control Department. The overall mean of lead across 18 spots was 6.03±0.15 – 1,208.87±0.17 mg/kg.

Amount of Cadmium in Soil

The analysis of cadmium in soil at the waste disposal site and in the rice fields surrounding the waste disposal site was reported in Figure 11.

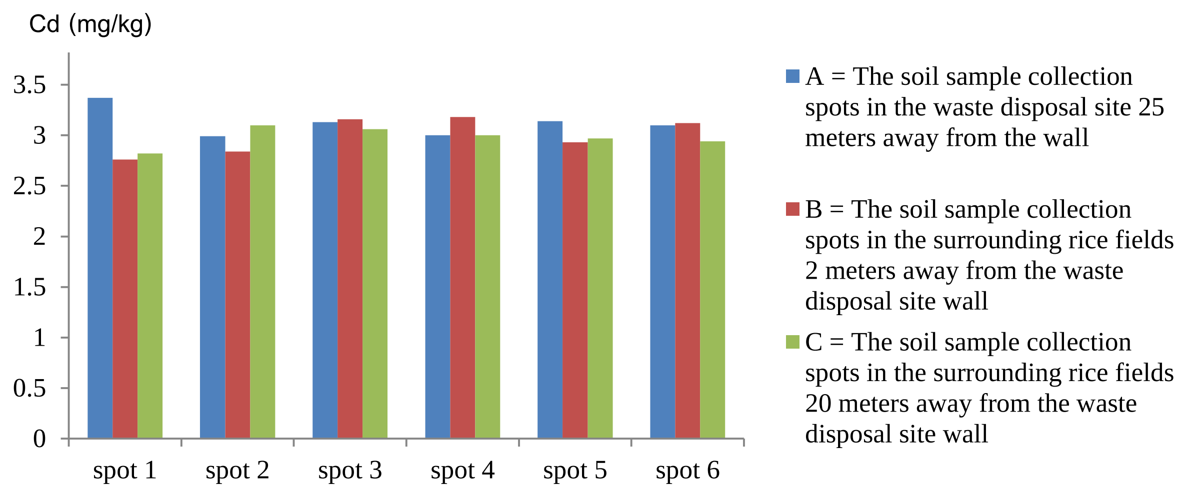

Figure 11 The mean of cadmium found in soils collected from the waste disposal site and the rice fields surrounding the waste disposal site of Khok Sa-at Subdistrict Administrative Organization

From Figure 11, it was found that the mean of cadmium in soils collected from the waste disposal site 25 meters (A) away from the wall showed mean of cadmium at 2.99±0.08 – 3.27±0.10 mg/kg. The lowest mean of cadmium was Spot 2A at 2.99±0.08 mg/kg and the highest mean of cadmium was Spot 1A at 3.27±0.10 mg/kg. The rice fields surrounding the waste disposal site 2 meters (B) showed mean of cadmium at 2.76±0.07 – 3.18±0.07 mg/kg. The lowest mean of cadmium was Spot 1B at 2.76±0.07 mg/kg and the highest mean of cadmium was 4B at 3.18±0.07 mg/kg. The examination of soils in the rice fields surrounding the waste disposal site 20 meters (C) away from the wall showed mean of cadmium at 2.82±0.07 – 3.10±0.07 mg/kg. The lowest mean of cadmium was Spot 1C was 2.82±0.07 mg/kg and the highest mean of cadmium was Spot 2C at 3.10±0.07 mg/kg. The examination of cadmium against the standards for agricultural use and residence prescribed the Pollution Control Department indicated that all soil sample collection spots were in line with the standards (37 mg/kg). The mean of cadmium in overall 18 spots was 2.76±0.07 – 3.27±0.10 mg/kg.

Amount of Copper in Soil

The analysis of copper in the soil samples collected from the waste disposal site and in the rice fields surrounding the site was reported in Figure 12.

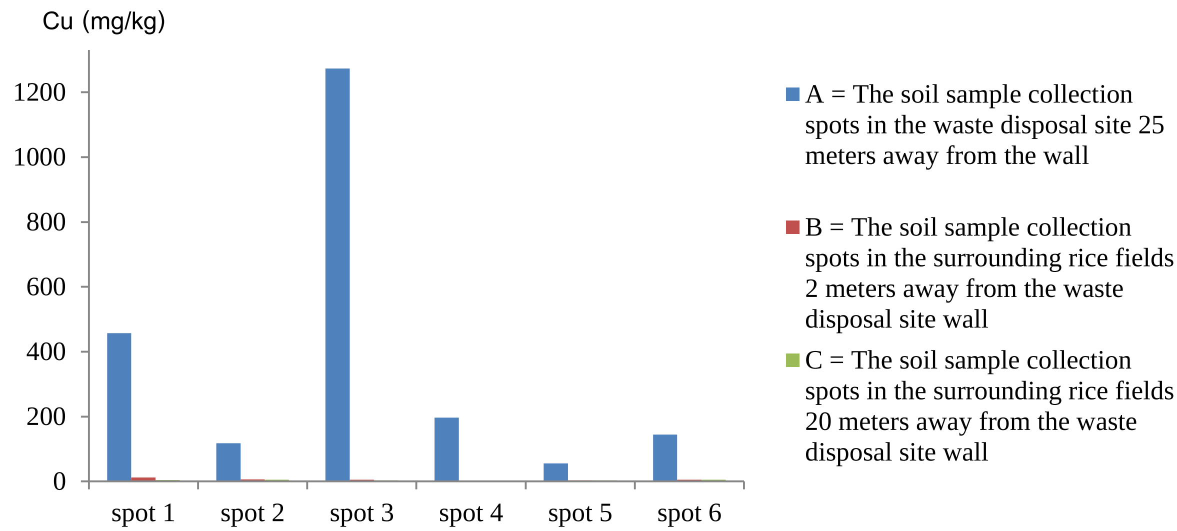

Figure 12 The mean of copper in the soil samples collected from the waste disposal site in different spots of the site at Khok Sa-at Subdistrict Administrative Organization

From Figure 12, the amount of copper found in the waste disposal site 25 meters (A) away from the wall showed the mean at 55.43±0.15 – 1,273.33±0.58 mg/kg. The lowest amount of copper was Spot 5A at 55.43±0.15 mg/kg and the highest copper was Spot 3A at 1,273.33±0.58 mg/kg. The rice fields surrounding the waste disposal site 2 meters (B) away from the wall showed the mean of copper at 2.18±0.07 – 12.21±0.08 mg/kg. The lowest amount of copper was Spot 4B at 2.18±0.07 mg/kg and the highest copper was Spot 1B at 12.21±0.08 mg/kg. The measurement of soils in the rice fields surrounding the waste disposal site 20 meters (C) away from the wall showed the mean of copper at 3.03±0.09 – 5.59±0.12 mg/kg. The lowest amount of copper was Spot 3C at 3.03±0.09 mg/kg and the highest copper was Spot 2C at 5.59±0.12 mg/kg. (There is no standard prescribed by the Pollution Control Department). The mean of copper across 18 spots was 2.18±0.07 – 1,273.33±0.58 mg/kg.

Discussion

pH : The soil pH in the waste disposal site 25 meters (A) away from the wall and in the rice fields surrounding the waste disposal site 2 meters (B) and 20 meters (C) away from the wall altogether 18 spots indicated that the pH mean was 4.05±0.01 – 8.46±0.00 which met with the soil quality standards for agricultural use and residence prescribed at 4.05±0.01 – 9.00±0.00. However, the pH of soils in the rice fields surrounding the waste disposal site 2 meters away from the wall for Spot 3B was 4.05±0.01 which meant the soil at this spot is extremely acidic or highly corrosive. The area showed waste cleaning water leaking through the soil surface from the waste disposal site. Acidic soil favor for heavy metal ions disintegration (Gao *et al*., 1994; Xie *et al*., 1991; Wang *et al*., 1995). Therefore, the highly acidic soil at the waste disposal site will lead to disintegration for ions of lead (Pb), cadmium (Cd) and copper (Cu) in the soil that resulted in the presence of heavy metals in the soil. It was found that Spot 3B showed high acidity which also lead to high EC at Spot 3B (240.67±0.58 μS/cm). This meant Spot 3B showed good ions breakdown of minerals. In addition, the pH positively affects the dissolution of nutrients in the soil in a form of solution mixed with water in the soil. If the soil pH is not appropriate, it favors very little only nutrients dissolved in the soil and thus insufficient for the needs of plants. On the other hand, some nutrients may excessively dissolve and become toxic to plants (Swietlik, 1992).

Electrical Conductivity : EC of soils from the waste disposal site 25 meters (A) away from the wall and in the rice fields surrounding the waste disposal site 2 meters (B) and 20 meters (C) away from the wall altogether 18 spots showed EC mean at 12.72±0.04 – 240.67±0.58 μS/cm. The EC found at the waste disposal site and in the rice fields indicated the ions disintegration capacity in the soil in which if the soil in any area shows high EC, it means the soil in that area has high disintegration of ions in the soil. Therefore, the soil in the waste disposal site and the surrounding rice fields showed high EC and it thus possessed high ions disintegration of the minerals. This also agreed with the pH detected in the soil of area under investigation which showed high acidity and this therefore favored good disintegration of ions in the soil.

Amount of Lead in Soil : The amount of detected lead was reported in regard to the soil from the waste disposal site 25 (A) meters away from the wall and in the rice fields 2 meters (B) and 20 meters (C) away from the wall altogether 18 spots across the soil sample collection Spot 1, 2, 3, 4, 5 and 6. It was found that Spot 3A 25 meters away from the waste disposal site wall showed the highest amount of lead at 1,208.87±0.15 mg/kg. That area is the waste burning spot leaving extensive remains of burnt e-waste, TV screen and plastic. It therefore showed higher level of lead in this area than other areas. The subsequent area was Spot 1A showing lead level at 247.40±4.73

mg/kg. This area is lower area adjacent to the waste cleaning water source and near the e-waste burning spot. This can cause contamination of lead in the area. The lead decreases in the soil sample collection spots further downwards into the rice fields. The examination of lead detected at the waste disposal site 25 meters (A) away from the wall and in the surrounded rice fields 2 meters (B) and 20 meters (C) away from the wall altogether 18 spots showed that the amount of lead at Spot 3B 25 meters away from the wall was 1,208.87±0.15 mg/kg which exceeded the standards of soil quality for agricultural use and residence prescribed by the Pollution Control Department at 400 mg/kg. It was found that the detected lead is in line with the standards of the Pollution Control Department.

Amount of Cadmium in Soil : The examination of cadmium in the soil at the waste disposal site 25 meters (A) away from the wall and in the rice fields surrounding the site 2 meters (B) and 20 meters (C) away from the wall altogether 18 spots covering Spot 1, 2, 3, 4, 5 and 6 showed the highest cadmium level of 3.27±0.10 mg/kg at Spot 1A adjacent to the e-waste cleaning and burning area e.g. phone batteries, circuit boards, TV parts, metal scraps, electrical appliances, etc. which leads to cadmium contamination or electronic waste products containing cadmium causing higher cadmium content in this area than other spots. The analysis of detected cadmium in the soil at the waste disposal site 25 meters, 2 meters and 20 meters away from the wall altogether 18 spots against the standards of soil quality for agricultural use and residence prescribed by the Pollution Control Department indicated that all soil sample collection spots were in line with the standards prescribed by the Pollution Control Department, that is, not exceeding 37 mg/kg. The results of this study were similar to the Regional Environment Office 10, Pollution Control Department (2014) in their summary report of environmental problems on the wastes from electrical products and electronic products in Khong Chai District, Kalasin Province. The amount of cadmium in the soil found at the waste disposal site of Khok Sa-at Subdistrict Administrative Organization was 12 mg/kg in line with the standards. Another similar study was Weichang, Ji., *et al.* (Ji *et al*., 2012) also reported detection of cadmium accumulation in the soil, rice fields, rice straws and rice grains. This meant that that cadmium can accumulate in soil and plants. Therefore, the plant can absorb cadmium in different parts. When animals consume plants containing cadmium, they will definitely intake cadmium. Cadmium is a toxic heavy metal, and when people consume meat from these animals, they will receive toxic substances accumulated in the body following the food chain system (Li *et al.*, 2016; Kobayashi *et al*., 2008).

Amount of Copper in Soil : The examination of copper in the soil at the waste disposal site 25 meters (A) away from the wall, and in the rice fields surrounding the site 2 meters (B) and 20 meters (C) away from the wall altogether 18 spots covering Spot 1, 2, 3, 4, 5 and 6 revealed that Spot 3A showed the highest level of copper at 1,273.33±0.58

mg/kg as the area contained substantial electronic waste burning and showing a pile of electronic waste such as remains of circuit boards, TV screen, wires left from burning. This clearly causes copper contamination or copper substances left from the burning of wires and thus the copper content in this area is higher than other areas. However, copper in the rice fields around the waste disposal site showed fewer copper content than the soil in the waste disposal site. Nevertheless, there is no specific criteria prescribed by the Pollution Control Department for copper detected in the environment.

Conclusions

The average pH value in the waste disposal site at area A, B, and C were 5.59±0.01 – 8.32±0.01, 4.05±0.01 – 8.46±0.00, and 4.62±0.00 – 7.57±0.01 respectively. The electrical conductivity values were at the range of 12.72±0.04 – 195.47±0.06, 17.38±0.09 – 240.67±0.58, and 17.81±0.20 – 190.23±0.06 µs/cm. respectively. Moreover, the heavy metals in the study with the Soil Quality Standards Criteria of the Pollution Control Department, the heavy metals content at most of the sampling areas met the standard level except the lead content at point 3A (1,208.87±0.15 mg/kg.) The solid waste disposal site of Khok Sa-at Subdistrict Administrative Organization should be strict on separation of electronic waste that contains heavy and hazardous metals as well as collective disposal and burning of electronic waste. There should also be measures in dealing with the person who discard and burn the waste in the waste disposal site. The related agencies should offer measures to prevent, control, and correct electronic waste separation to reduce problems on soil quality and environmental toxicity in the future.

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