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# Analysis of Physio-chemical Parameters and Distribution of Heavy Metals in Soil and Water of Ex-Mining Area of Bestari Jaya, Peninsular Malaysia

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This paper includes preliminary soil and water analysis of former tin mining area of Bestari Jaya. The whole catchment covers an area of 2656.31 hectares. The present study area covers 92 hectares of catchment which includes two water ponds that flow downstream to Sungai Ayer Hitam that ultimately ends up into Sungai Selangor. Initially physio-chemical parameters and concentration of heavy metals $Pb^{2+}$, $Zn^{2+}$, $Ni^{2+}$, $Co^{2+}$, $As^{3+}$, $Cu^{2+}$, $Fe^{2+}$, $Mn^{2+}$, $Sn^{2+}$ in soil and ponds were evaluated. The metals are extracted by nitric acid and hydrogen peroxide in a closed vessel microwave digestion system and analyzed by using atomic absorption spectroscopy. The method is validated by using standard reference material (NIST SRM 4354, 1643e) and results were compared with interim national water quality standards for Malaysia and found that the soil and water quality of area is degraded so it is concluded that Bestri Jaya ex-mining catchment has a high pollution potential due to mining activities and Sungai Ayer Hitam, recipient of catchment water is a highly polluted river. Different environmental aspects have also discussed in this paper for the future research during this project.

**Key Words: Water quality, Heavy metals, Soil, Water, Ex-mining.**

## INTRODUCTION

Tin mining was one of the leading mining industry in Malaysia during 19th century and have contributed a lot in the socio-economic development of the country. Malaysia was one of the largest tin producers until the tin crisis[1] of 1985. Malaysia's tin deposits occur in a strip of land about 400 Km long and 60 Km wide between the town of Georgetown and Melaka, along the western coast of Peninsular Malaysia. Most Malaysian tin comes from two states Perak and Selangor, which together account for about 90 % of the country's tin mining output[2].

After the discovery of tin many methods have been used for mining of tin in Malaysia. In the start panning and open cast mining were normally used. Other methods include lampanning and dredging[3]. 'Lampanning' (ground-sluicing on hillsides) was the most destructive form of tin mining. In certain areas where it was extensively practised, it left a persistent legacy of disturbed and scarred land. 'Lampanning' operations also constituted a major source of sediment and contributed to the siltation of rivers in mining areas and to more frequent flooding in subsequent years[4]. After the mining operations has carried out, it left behind ponds, lakes, tin tailings (sand and slime tailings) and areas of mixed material. It is estimated that there are about 210,000 hectares ex-mining land in the country and most areas has been rehabilitated into useful land[1]. According to JMG (Jabatan Minerals dan Gesoains, 2008) there is 4909.6 hectares examining land in Selangor and the area under study still needs to be rehabilitation.

Besides employment and economic profit, there are a lot of environment hazards also associated as well. These may include threat to natural reserves due to landscape changes, damage to natural drainage, pollution and destruction of natural habitats[5]. The environmental problems caused by tin mining have been lessened with the help of governments in legislations in Malaysia. Some of these are The mining codes of Perak (1895) and Negeri Sembilan (1895), The mining enactment No. 7 (1899), the selangor mining enactment[3] (1901), (1911), (1921), (1928) *etc*. Most of these laws were mainly concerned on mining code of practice but not purely discuss environmental issues so The F.M.S. mining enactment (1934) was the first to introduce some environmental standards[3]. They passed laws which required tin mining companies to carry out restoration work after they have mined a parcel of excavated land[3].

The preliminary investigation of soil and water chemistry of the proposed site will help to get the ground information about environmental and contamination characteristics and to get guidelines for detailed planning of the work in future. As Selangor state is the most populated state in Malaysia and is shortage of land. This project will also be valuable for rehabilitation and reclamation of the study area for safer economic development of the state and country.

**Description of the study area:** The study area Bestari Jaya catchment is located at 3º, 24' 40.41" N and 101º 24' 56.23" E is part of Daerah Kuala Selangor in Selangor state that includes three towns Mukim Batang Berjuntai, Mukim Ulu Tinggi, Mukim Tg.karang.

The Bestari Jaya is an old tin mining area for over 10 years. The whole catchment covers an area of 2656.31 hectares which is located downstream at the embankment of Kampung Bestari Jaya and University Industry Selangor (UNISEL) main campus. The catchment flow downstream to Sungai Ayer Hitam and Sungai Udang which ultimately ends up with Sungai Selangor at 5 Km upstream of Batang Berjunti Water Treatment Plants SSP1 and SSP2 which are major water distributors to federal territory (Kuala Lumpur and Putrajaya) and Selangor state as well.

The area consists of myriad ecosystems which can be subdivided into several categories such as degraded land, large open lakes and small ponds, earth drains and wetlands area, tin tailings (sand and slime tailings), logged peat swamp forest land in east. The contribution of storm water, peat swamp forest water and recent sand mining activity has caused severe environmental pollution due to drainage problem in the area. The area has a lot of big lakes and small ponds that are interconnected by earth drains. Excess water from these lakes and ponds is discharged to the existing earth drains at the downstream of the lakes and ponds. Precipitation rate is high in some stagnant ponds.

Flow routing had been carried out by applying the survey data. Some of the lakes flow across the downstream into open spaces and wetlands that run off into Sungai Ayer Hitam, meets up Sungai Udang and ultimately ends up to Sungai Selangor at the Jalan Timur Tambahan road junction, east of UNISEL.

In the study area Sungai Selangor has an average water depth 5.7 meter, channel width 8.4 meter and river flow 54.6 $m^3/s$. Ayer Hitam has an average water depth 1.7 meter, channel width 5 meter and river flow is 21.5 $m^3/s$ while Sungai Udang (the smallest channel) has an average water channel depth of 32 cm, channel width 110 cm and 42 $m^3/s$.

The wetlands has an area of 579.7 hectares is stretched along the north western border of the site. Several useful plant species have been seen in the wetland while several harmful weed species have been also seen in the study area that cause blocking of water courses and water become foul due to large masses of water leaves. This area is sandy in texture and it is representative of entire examining area in the country. The parent material is of reverine alluvium materials, with pH in range of 3.5-5.5.

## EXPERIMENTAL

**Sampling location:** In preliminary analysis 92 hectares of downstream part of the catchment were analyzed that includes drain of catchment to Sungai Ayer Hitam that meets Sungai Selangor at the Jalan Timur Tambahan road junction. Water samples were taken from two ex-mining ponds, at the junction of Sungai Ayer Hitam and at the junction of Sungai Selangor and soil samples were taken at the embankment of the river and ponds and the area nearby.

**Sampling and preservation:** Due to large study area global positioning system (GPS) was used to determine the actual coordinates of the sampling sites and to reconfirm the location of the sampling site during subsequent sampling periods. In preliminary studies soil and water investigation consists of ten locations, in order to determine and to provide ground information for subsequent detailed planning of the future work. For soil sampling multiple sub samples were taken from each location and then samples were homogenized into composite sample with stainless spoon and then sub sampled by spoon into each sample container to get accurate results. For *ex situ* analysis, soil samples were collected from first 20 cm of the soil in polythene bags and water samples were collected 10 cm below the surface water using HDPE bottle 500 mL[6]. The water samples were preserved by few drops of nitric acid (70 %) and stored in an icebox and transported to laboratory for analysis.

**Water investigation:** In preliminary studies two ponds at downstream of the catchment were investigated for physio-chemical parameters and heavy metals analysis. Physio-chemical parameters were analyzed by instrument Hydro lab HACH MS5 while colour of water is measured by true colour units (TCU). For quantitave estimation of heavy metals, samples were digested by acid digestion method[7] and analyzed by atomic absorption spectrophotometer.

**Soil investigation:** Soil physico-chemical parameters measured were soil texture, temperature, hydraulic conductivity, moisture content, soil pH and soil grain size. Texture is determined by Bouyoucos method[8], soil temperature by soil thermometer, hydraulic conductivity by ASTM D5084-03 method[9], moisture content by gravimetric method, soil pH was measured by potentiometrically[10] and soil grain size was measured by ASTM D422 method[11]. For estimation of heavy metals the samples were air dried, crushed in a mortar pestle and sieved up to 0.5 mm mesh sieve and then digested by wet digestion method and analyzed by a Perkin-Elmer A Analyst 800 atomic absorption spectrophotometer.

## RESULTS AND DISCUSSION

Water quality parameters for 15 sampling stations are shown in (Table-1). Results shows that there is variation in water quality at all sampling stations. Water quality parameters of sampling station WS15 are; colour 9 TCU, temperature 32.51 ºC, pH 5, conductivity 1756 μmhos/cm, salinity 0.30 %, turbidity 0.22 NTU, dissolved oxygen 6.82 mg/L, total dissolved solids 2998 mg/L while at WS1 (Junction of Sungai Ayer Hitam + Sungai Selangor) water quality parameters are; colour 5 TCU, temperature 32.19 ºC, pH 6.47, conductivity 1640 μmhos/cm, salinity 0.26 %, turbidity 0.12 mg/L dissolved oxygen 6.59 mg/L, total dissolved solids 2654 mg/L. This shows variation trends at all sampling stations are from upstream to downstream. Possible factors involved in this variation may include formation of wetlands, palm oil plantation and the dilution factor of water.

TABLE-1
PHYSIO-CHEMICAL PARAMETERS OF SURFACE WATER IN THE STUDY AREA

| Sample No. | Location | Coordinates | Colour TCU | Temp. (°C) | pH | Conductivity (µS/cm) | Salinity (%) | Turbidity NTU | Dissolved oxygen (mg/L) | Total dissolved solids (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| WS1 | Junction of Sungai Selangor + Sungai Ayer Hitam | 3° 24' 28.04" N 101° 25' 54.89" E | 5 | 32.19 | 6.47 | 1640 | 0.27 | 16 | 6.83 | 2654 |
| WS2 | Junction of Sungai Ayer Hitam + Sungai Udang | 3° 24' 30.96" N 101° 25' 54.08" E | 7 | 32.62 | 6.27 | 1680 | 0.28 | 18 | 6.65 | 2784 |
| WS3 | Sungai Ayer Hitam water flow | 3° 24' 36.54" N 101° 25' 59.96" E | 7 | 32.52 | 6.27 | 1686 | 0.28 | 18 | 6.70 | 2797 |
| WS4 | Sungai Ayer Hitam at bank of UNISEL | 3° 24' 56.68" N 101° 25' 59.18" E | 7 | 32.51 | 6.29 | 1686 | 0.28 | 18 | 6.72 | 2800 |
| WS5 | Sungai Ayer Hitam at bank of UNISEL | 3° 25' 06.69" N 101° 26' 08.14" E | 7 | 32.98 | 6.29 | 1688 | 0.28 | 19 | 6.15 | 2812 |
| WS6 | Junction of Pond 1 to Sungai Ayer Hitam | 3° 25' 16.57" N 101° 26' 09.24" E | 7 | 32.90 | 6.28 | 1690 | 0.28 | 18 | 6.42 | 2864 |
| WS7 | Pond 1 | 3° 25' 13.37" N 101° 26' 04.66" E | 7 | 32.75 | 5.78 | 1704 | 0.29 | 19 | 6.34 | 2900 |
| WS8 | Pond 1 | 3° 25' 15.56" N 101° 26' 0.79" E | 7 | 32.50 | 5.20 | 1744 | 0.29 | 20 | 6.00 | 2934 |
| WS9 | Junction of Pond 1 to another Pond | 3° 25' 13.87" N 101° 25' 55.35" E | 7 | 32.44 | 5.32 | 1734 | 0.29 | 19 | 6.42 | 2924 |
| WS10 | Junction of Sungai Ayer Hitam to Pond 2 at north-eastern boundary UNISEL | 3° 25' 20.92" N 101° 26' 12.06" E | 7 | 32.28 | 5.41 | 1694 | 0.28 | 18 | 6.39 | 2887 |
| WS11 | Junction of Sungai Ayer Hitam to Pond 2 | 3° 25' 22.11" N 101° 26' 6.66" E | 9 | 32.32 | 5.34 | 1710 | 0.28 | 20 | 6.28 | 2912 |
| WS12 | Pond 2 | 3° 25' 22.54" N 101° 26' 0.94" E | 9 | 32.12 | 5.22 | 1724 | 0.29 | 22 | 6.87 | 2920 |
| WS13 | Pond 2 | 3° 25' 22.05" N 101° 25' 58.38" E | 9 | 32.57 | 5.39 | 1732 | 0.29 | 24 | 6.45 | 2922 |
| WS14 | Pond2 | 3° 25' 23.71" N 101° 25' 52.42" E | 9 | 32.29 | 5.28 | 1738 | 0.29 | 22 | 6.59 | 2956 |
| WS15 | Junction of Pond 2 to another Pond | 3° 25' 33.21" N 101° 25' 51.34" E | 9 | 32.51 | 5.00 | 1756 | 0.30 | 22 | 6.82 | 2998 |
| Mean ($\overline{X}$) | | | 7 | 32.5 | 5.71 | 1707 | 0.28 | 0.19 | 6.50 | 2870 |
| Standard deviation (O') | | | 1.18 | 0.24 | 0.52 | 30.83 | 0.00700 | 2.130 | 0.25 | 87.26 |
| Variance (Standard deviation) ($O'^2$) | | | 1.40 | 0.06 | 0.27 | 950.78 | 0.00006 | 4.552 | 0.06 | 7615.49 |

Comparison with Malaysian Interim Water Quality Standards (INWQS), (Table-1) showed that at all sampling stations colour lies between 5-9 TCU so it falls in class I, temperature in normal range, pH class III, electric conductivity falls class III, salinity in class I, turbidity in class I, dissolved oxygen in class II and total dissolved solids in class III. Acidic pH and low dissolved oxygen is the characteristic of peat swamp water (flowing into the catchment) and also by metal and sand mining activity. The high conductivity values represent high concentration of total dissolved solids. The main source of high TDS value is the recent sand mining activity going on in the study area. This study shows that the water quality is degraded in the area.

Tables 2 and 3 shows the physico-chemical properties of soil. Table-2 shows that the average contents of the soil are gravel 37.3 % with diameter 3-6 mm, sand 57.20 % with diameter 0.1-2.0 mm, silt 2.9 % with diameter 0.008-0.4 mm and clay 2.46 % with diameter 0.0008-0.0014 mm that is kind of medium textured sandy soil. Sandy soils have low clay and organic matter contents and aggregation is very weak to non-existent. The structure is called single grained. Such kind of soil cannot retain so much water and can drain quickly. Single drained soils required frequent irrigation and fertilization for plants roots to penetrate. Table-3 indicates that the average moisture content of soil is 6.36 % of soil, temperature 22.0 ºC, pH 5.64 and hydraulic conductivity is 13.7 cm/day. This shows that the soil temperature and hydraulic conductivity is feasible for plant growth but low pH due to high cations in soil and moisture content due to sandy structure depress plant growth.

Metal concentration of water and soil are good indicators of degree of contamination. Table-4 shows the concentration of heavy metals in water of the area under investigation. At the sampling station WS1 are as follows; lead 38 mg/L, zinc 88 mg/L, nickel 2.5 mg/L, cobalt 1.0 mg/L, arsenic 30 mg/L, copper 59 mg/L, iron 06 mg/L, manganese 44 mg/L and tin 85 mg/L while at sampling station WS15 concentration of heavy metals are as follows; lead 96 mg/L, zinc 121 mg/L, nickel 2.8 mg/L, cobalt 1.8 mg/L, arsenic 77 mg/L, copper 80 mg/L, iron 16 mg/L, manganese 48 mg/L and tin 250 mg/L. Same variation trends of decrease in metal concentration are at all sampling stations from upstream to down stream. According to Jabatan Meterologi Malaysia 1995, Bestari Jaya is a flooding area with average rainfall 2670 mm, annual precipitation 1800 mm and average wind speed upto 10 km/h so the possible causes of this decrease in metals concentration

TABLE-2
GRAIN SIZE ANALYSIS OF THE SOIL

| Sample No. | Location | Coordinates | Gravel | | Sand | | | | | Silt | | Clay | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Course to medium | | Fine | | | | | | |
| | | | PD | % | PD | % | PD | % | Total (%) | PD | % | PD | % |
| SS1 | Junction of Jalan Timur Tambahan + Sungai Selangor | 3° 24' 29.80" N 101° 25' 55.08" E | 4 | 37.66 | 1 | 32.01 | 0.1 | 25.34 | 57.35 | 0.04 | 2.81 | 0.0014 | 2.18 |
| SS2 | Bank of Sungai Ayer Hitam + Sungai Udang | 3° 24' 32.03" N 101° 25' 54.75" E | 5 | 37.98 | 2 | 30.45 | 0.2 | 26.73 | 57.18 | 0.02 | 2.40 | 0.0009 | 2.44 |
| SS3 | Bank of Sungai Ayer Hitam | 3° 24' 36.29" N 101° 25' 57.34" E | 3 | 35.44 | 1 | 29.48 | 0.1 | 27.52 | 57.00 | 0.02 | 3.88 | 0.0008 | 3.68 |
| SS4 | South-eastern boundary of UNISEL | 3° 24' 54.73" N 101° 26' 0.48" E | 6 | 38.41 | 2 | 30.18 | 0.3 | 27.36 | 57.54 | 0.04 | 2.57 | 0.0016 | 1.48 |
| SS5 | Wetlands developed by overflow of Pond 1 | 3° 25' 09.78" N 101° 25' 59.41" E | 5 | 36.98 | 1 | 31.24 | 0.3 | 25.57 | 56.81 | 0.01 | 2.88 | 0.0016 | 3.38 |
| SS6 | Bank of Pond 1 | 3° 25' 11.54" N 101° 26' 07.44" E | 4 | 37.52 | 2 | 31.12 | 0.2 | 26.60 | 57.72 | 0.009 | 2.67 | 0.0019 | 2.09 |
| SS7 | North-eastern boundary of UNISEL | 3° 25' 13.40" N 101° 26' 11.64" E | 3 | 37.84 | 2 | 30.52 | 0.2 | 25.92 | 56.44 | 0.02 | 3.13 | 0.0018 | 2.59 |
| SS8 | Wetlands developed by overflow of Pond 1 | 3° 25' 59.18" N 101° 25' 56.90" E | 4 | 36.85 | 2 | 29.92 | 0.2 | 26.34 | 56.26 | 0.008 | 3.98 | 0.0019 | 2.91 |
| SS9 | Junction of Sungai Ayer Hitam with pond 1 on north-western side | 3° 25' 19.80" N 101° 26' 13.07" E | 5 | 35.94 | 2 | 30.74 | 0.1 | 26.40 | 57.14 | 0.1 | 3.76 | 0.0016 | 3.16 |
| SS10 | Junction of Sungai Ayer Hitam with pond 1 on south-western side | 3° 25' 22.79" N 101° 26' 11.06" E | 5 | 37.72 | 2 | 29.12 | 0.1 | 27.86 | 56.98 | 0.3 | 2.81 | 0.0008 | 2.49 |
| SS11 | Wetland between Pond 1 and Pond 2 | 3° 25' 20.64" N 101° 25' 54.37" E | 4 | 37.44 | 1 | 31.19 | 0.3 | 27.15 | 58.34 | 0.4 | 2.21 | 0.0008 | 2.01 |
| SS12 | Embankment of Pond 2 | 3° 25' 27.52" N 101° 25' 53.89" E | 3 | 37.74 | 1 | 32.92 | 0.2 | 25.47 | 58.39 | 0.2 | 2.10 | 0.0009 | 1.77 |
| SS13 | Embankment of Pond 2 | 3° 25' 22.86" N 101° 25' 51.67" E | 6 | 37.54 | 2 | 31.44 | 0.4 | 26.13 | 57.57 | 0.2 | 2.56 | 0.0014 | 2.33 |
| SS14 | Embankment of Pond 2 | 3° 25' 34.95" N 101° 25' 49.93" E | 3 | 37.75 | 2 | 30.88 | 0.3 | 25.71 | 56.59 | 0.3 | 3.12 | 0.0016 | 2.54 |
| SS15 | Embankment of Pond 2 | 3° 25' 36.24" N 101° 25' 52.14" E | 5 | 37.58 | 1 | 31.12 | 0.2 | 26.76 | 57.88 | 0.009 | 2.62 | 0.0018 | 1.92 |
| Mean ($\overline{X}$) | | | 4.33 | 37.35 | 1.6 | 30.82 | 0.2 | 26.45 | 57.20 | 0.11 | 2.9 | 0.0013 | 2.46 |
| Standard deviation (O') | | | 1.04 | 0.77 | 0.50 | 0.95 | 0.09 | 0.78 | 0.63 | 0.13 | 0.57 | 0.0004 | 0.61 |
| Variance (Standard deviation) ($O'^2$) | | | 1.09 | 0.60 | 0.25 | 0.91 | 0.008 | 0.61 | 0.40 | 0.01 | 0.33 | 0 | 0.37 |

PD = Particle diameter (mm)

TABLE-3
PHYSIO-CHEMICAL PARAMETERS OF SOIL IN THE STUDY AREA

| Sample No. | Moisture content % by weight | Temp. (°C) | pH | Hydraulic conductivity (cm/day) |
|---|---|---|---|---|
| SS1 | 6.23 | 21.22 | 5.7 | 14.3 |
| SS2 | 6.24 | 22.84 | 5.5 | 12.4 |
| SS3 | 6.38 | 21.44 | 5.3 | 15.2 |
| SS4 | 6.43 | 22.19 | 5.3 | 12.9 |
| SS5 | 6.52 | 22.92 | 5.4 | 13.8 |
| SS6 | 6.18 | 21.14 | 5.8 | 12.5 |
| SS7 | 6.34 | 22.81 | 5.7 | 13.6 |
| SS8 | 6.48 | 22.45 | 5.8 | 13.7 |
| SS9 | 6.44 | 21.91 | 5.8 | 14.1 |
| SS10 | 6.30 | 21.65 | 5.8 | 14.5 |
| SS11 | 6.38 | 22.24 | 5.4 | 14.8 |
| SS12 | 6.41 | 21.14 | 5.8 | 13.8 |
| SS13 | 6.28 | 22.34 | 5.1 | 12.9 |
| SS14 | 6.39 | 21.87 | 5.8 | 14.6 |
| SS15 | 6.43 | 22.39 | 5.7 | 13.3 |
| Mean ($\overline{X}$) | 6.36 | 22.0 | 5.6 | 13.7 |
| Standard deviation (O') | 0.09 | 0.61 | 0.23 | 0.84 |
| Variance (Standard deviation) ($O'^2$) | 0.009 | 0.37 | 0.05 | 0.71 |

are natural aeration, natural precipitation other possible causes of decrease in metal concentration are formation of wetlands, palm oil plantation and the dilution factor of water as it flows downstream.

Table-4 shows heavy metals concentration in soil. Concentration is even higher in soil as compared to water. Comparison of metal concentration in water and soil with Interim National Water Quality Standards Malaysian (INWQS) shows that the heavy metals concentration falls above class IV so it shows that the study area has a high pollution impact on the environment. It also shows the variation trends about metals concentration in soil and water at the catchment, Sungai Ayer Hitam and Sungai Selangor. Metals concentration decreased as water flows from catchment to Sungai Selangor but in soil no such trends are observed so it can be concluded that main causes of decrease are precipitation, aeration and formation of wetlands that acts as a filter for the heavy metals.

**Future concerns**

**Morphology and characterization of lakes and ponds:** About 4909.60 hectares of land in Selangor were under mining leases at the end of 2000 and most of these lands have been

TABLE-4
HEAVY METALS CONCENTRATION IN SOIL AND SURFACE AREA OF THE STUDY AREA

| Sample No. | Element concentration (mg/kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $Pb^{2+}$ | $Zn^{2+}$ | $Ni^{2+}$ | $Co^{2+}$ | $As^{3+}$ | $Cu^{2+}$ | $Fe^{2-}$ | $Mn^{2+}$ | $Sn^{2+}$ |
| SS1 | 110 | 120 | 8.5 | 3.0 | 70 | 120 | 22 | 84 | 425 |
| WS1 | 38 | 88 | 2.5 | 1.0 | 30 | 59 | 06 | 44 | 85 |
| SS2 | 96 | 113 | 5.5 | 2.8 | 75 | 112 | 24 | 91 | 400 |
| WS2 | 46 | 86 | 2.5 | 2.1 | 35 | 78 | 10 | 46 | 100 |
| SS3 | 110 | 132 | 6.1 | 2.0 | 82 | 128 | 25 | 72 | 390 |
| WS3 | 45 | 86 | 3.1 | 2.0 | 32 | 68 | 12 | 46 | 150 |
| SS4 | 115 | 110 | 6.6 | 2.9 | 86 | 135 | 25 | 84 | 350 |
| WS4 | 51 | 87 | 3.6 | 1.9 | 36 | 76 | 15 | 47 | 150 |
| SS5 | 120 | 122 | 7.9 | 2.0 | 62 | 140 | 25 | 89 | 355 |
| WS5 | 51 | 86 | 2.9 | 2.0 | 52 | 69 | 13 | 49 | 155 |
| SS6 | 102 | 121 | 7.5 | 2.9 | 78 | 137 | 25 | 81 | 338 |
| WS6 | 60 | 88 | 7.5 | 2.9 | 78 | 71 | 10 | 49 | 200 |
| SS7 | 108 | 100 | 8.1 | 2.5 | 91 | 125 | 26 | 79 | 325 |
| WS7 | 58 | 88 | 8.1 | 2.5 | 91 | 60 | 12 | 48 | 225 |
| SS8 | 99 | 120 | 6.2 | 2.8 | 88 | 100 | 26 | 86 | 368 |
| WS8 | 89 | 90 | 6.2 | 2.8 | 88 | 80 | 15 | 49 | 268 |
| SS9 | 97 | 102 | 7.3 | 3.0 | 67 | 125 | 28 | 98 | 387 |
| WS9 | 67 | 90 | 4.3 | 3.0 | 67 | 75 | 20 | 48 | 227 |
| SS10 | 120 | 112 | 6.4 | 2.7 | 91 | 120 | 25 | 98 | 399 |
| WS10 | 80 | 92 | 3.4 | 2.7 | 91 | 70 | 14 | 48 | 199 |
| SS11 | 85 | 100 | 5.9 | 2.9 | 69 | 128 | 26 | 81 | 434 |
| WS11 | 89 | 94 | 5.9 | 2.9 | 69 | 78 | 18 | 49 | 134 |
| SS12 | 99 | 132 | 8.1 | 2.8 | 90 | 125 | 25 | 83 | 455 |
| WS12 | 91 | 132 | 8.1 | 1.8 | 90 | 95 | 19 | 51 | 155 |
| SS13 | 97 | 110 | 6.2 | 2.1 | 89 | 130 | 28 | 90 | 490 |
| WS13 | 87 | 110 | 6.2 | 2.1 | 89 | 81 | 20 | 50 | 190 |
| SS14 | 110 | 122 | 5.5 | 3.5 | 71 | 128 | 24 | 81 | 498 |
| WS14 | 94 | 122 | 5.5 | 2.5 | 71 | 88 | 18 | 49 | 198 |
| SS15 | 110 | 121 | 5.8 | 2.8 | 77 | 130 | 29 | 86 | 450 |
| WS15 | 96 | 121 | 2.8 | 1.8 | 77 | 80 | 16 | 48 | 250 |
| Mean ($\overline{X}$) (In soil) | 105 | 115 | 6.7 | 2.7 | 79 | 125 | 25.5 | 85 | 404 |
| Mean ($\overline{X}$) (In surface water) | 69.46 | 87.8 | 4.8 | 2.2 | 66 | 75 | 14 | 48 | 179 |
| Standard deviation (O') (In soil) | 9.81 | 10.24 | 1.02 | 0.41 | 9.80 | 9.94 | 1.76 | 6.92 | 53.46 |
| Standard deviation (O') (In surface water) | 20.70 | 31.96 | 2.06 | 0.55 | 23.36 | 9.56 | 4.10 | 1.75 | 52.53 |
| Variance (Standard deviation) ($O'^2$) (In soil) | 96.31 | 105 | 1.05 | 0.14 | 96.20 | 98.98 | 3.12 | 47.98 | 2858 |
| Variance (Standard deviation) ($O'^2$) (In surface water) | 428.55 | 1021.7 | 4.24 | 0.30 | 546.11 | 91.45 | 16.83 | 3.06 | 2760 |

mined out for tin ore with open cast palong or dredging method[12]. What is left from these mining activities are hundreds of small ponds and big lakes that vary in sizes from few tens square meters to 50 hectares or more. So present work is the structuring and characterization of these lakes and ponds in terms of in terms of length, width, depth, zonation, inflow and outflow, type and shape, location on coordinates and the nature of the surroundings. The purpose of this study is to make rehabilitation and reclamation process more smooth and feasible for the state government.

**Water quality:** Surface water resources have played an important role throughout the history in the development of human civilization. About one third of the drinking water requirement of the world is obtained from surface sources like rivers, canals and lakes[13]. Water quality is affected by a wide range of natural and human influences. The most important of the natural influences are geological, hydrological and climatic, since these affect the quantity and the quality of water available. Due to tin mining activity the water quality of the whole catchment is degraded. The purpose of this study is to understand physical, chemical and biological characteristics of lakes and pond water and to access environmental impact through drainage into Sungai Selangor and to check the possibility of using pond water for live stock, irrigation or portable water.

**Metals distribution, speciation and transport in water, soil, sediments and plants:** Heavy metals originate within the earth. But human activities opened Pandora's box by spreading these toxic metals throughout the environment. The levels have risen in air, water and topsoil. High concentration of some of the heavy metals have direct effects on the growth of crops while some don't have direct effect but may effect the animals feeding on the crops[14]. So ultimate effect is on our body, contributing to chronic diseases, learning disorders, cancer, dementia and premature aging. So the purpose of the study is to check the distribution, speciation and transport in water, soil, sediments and plants in order to determine the ultimate effect of these metals on the environment.

**Tin tailings:** Tin tailings have been defined as tracts of waste land made up of washed waste products of alluvial mining. The tailing consists of two fractions: sand tailings and slime tailings, the former is very coarse textured and shows an absence of aggregation and profile development. The slime tailings consists mainly of very fine soils and minerals (silt and clay) and has compact structure. In terms of fertility the tin tailings are extremely deficient in almost all nutrients and have very low water retention capacity[15]. Continuous mining operations in Malaysia began about 150 years ago have resulted in large areas of barren land called tin tailings. It is estimated that about 250000 hectares of landfall in this category[16].

Bestari Jaya is one of the oldest tin mining area in Selangor. Over a century of tin mining has produced a large amount of tin tailings or "Amang", a bye product ore tin mining. Amang is a Malaysian term. It consists of a group of heavy minerals which occur together with the tin ore recovered from the alluvium. The constituents of amang are monazite, ilmenite, zircon, xenotime, rutile and some other minerals[17]. Of the amang contents monazite and xenotime have substantial amounts of thorium and uranium which are radioactive and provide high external dose rates in the work place, storage room and to the environment[18]. The purpose of the study is to access the concentration of radioactive elements uranium and thorium in the area.

**(A) Sand tailings:** Land which has been mined has now been turned into barren wasteland with mined out pounds surrounded by mounds of tailings sand. These tailings sand are presently exploited for use as construction sand[19]. Due to recent sand mining operations in the area, the concentration of TSS and TDS has increased in water which ultimately causes the growth of sediments in Sungai Selangor and also high concentration of metals in riverine sediments.

**(B) Slime tailings:** Tin mining in the study area was carried out mainly in the alluvium rich concentrations of cassiterite which were found on the valley floor or which were trapped within the troughs of pinnacled limestone. The end result of mining in almost all cases is the formation of pond. The present investigation is to study slurry slime at the ponds bottom. To improve the properties of slurry slime that has little or no bearing and shear strength and also to determine that the concentration of metals in slurry slime is hazardous to environment and whether the concentration of heavy metals in the slurry slime conform to the norm of earths' crust or are similar to that in the stream sediments

**Rehabilitation and reclamation:** While talking about mining activity, one cannot escape from the issues of safety and environment. Interestingly both issues are equally important while the mine is operating and also after it is closed. From the point of safety, a mine should be made safe even after its closure and from the point of environment a mine site should be rehabilited so as to make it useful instead of leaving it as waste land. Mined out land usually has almost all of its infertile topsoil and fine clay being washed, resulting in infertile, loose and dry soil unsuitable for vegetation. Rehabilitation cost is usually high. From the engineering aspect they are problematic since slime contents causes differential settlement that in turn gives problems to foundation of roads and buildings. Due to rapid urbanization in the state, Selangor has greatly increased the size of built up areas. Many urban areas have expanded to mined out land which has numerous ponds. It is estimated that the urban population will double itself every ten to 15 years[20] and mined out ponds in the way of urban expansion will be reclaimed and utilized for the construction of industrial, recreational and residential centres. Many methods have been adopted for reclaiming ex-mining lakes and ponds. The most commonly used method is the developing of housing estates and industrial parks is to lower the water level of the ponds and emplace fill material from one end of the pond[21]. Similar kind of method is adopted by Selangor Estate Government to rehabilitate the ex-mining area of Bestari Jaya for the development of University Industry Selangor (UNISEL). Two other methods of reclamation are Displacement method and The Containment Method[22]. The purpose of the study is to make the rehabilitation and reclamation process more feasible and cheaper.

## Conclusion

The preliminary result obtained from this study is alarming. The results of water quality trends clearly show that majority of water quality parameters are quite high and fall in class III in terms of Malaysian Interim Water Quality Standards. The picture is more severe if we think in terms of heavy metals concentration in the area. It falls above level IV in INWQS. After comparison of different parts of study area it is concluded that Bestari Jaya catchment has high pollution risks on environment, Sungai Ayer Hitam recipient of catchment water is highly polluted river that ultimately ends into Sungai Selangor, is vulnerable and sensitive ecosystem especially to metal pollution. Therefore lot of research needs to be carried out to access the pollution impact of the area on the environment and for the rehabilitation and reclamation steps to be taken.

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