**Midterm Progress Report**

# Mekong-ROK Cooperation Fund (MKCF)

| **A. Brief Project Information** | |
|---|---|
| 1.1. Project title | Assessment of Heavy Metal Contamination in Soil and Water for Safety Crop Production in Myanmar |
| 1.2. Country (s) / region | Myanmar |
| 1.3. Project area- Kyaunggon Township in Ayeyarwady Region, Tatkon Township in Naypyitaw Union Territories, Kalaw Township in Shan State (South), Kyautse in Mandalay Region | |
| □ Culture and Tourism<br>□ Human Resources Development<br>□ Agriculture and Rural Development<br>□ Infrastructure<br>□ Information and Communication Technology (ICT)<br>□ Environment<br>□ Non-traditional Security Challenges | |
| 1.4. Implementation start/end date | |
| Implementation start date<br>Implementation end date<br>Project lifespan | 01.10.2022<br>01.04.2024<br>18 months |
| **B. Prepared by** | |
| Name:<br>Title:<br>Department: | - U Win Oo, Dr. Thandar Nyi, Mrs Naing Naing Moe, Dr. Seinn Seinn Mu, Dr. Cho Mar Htwe, Dr.Daisy Myint, Mrs. May Phyoe Way<br>- Land Use Division, Department of Agriculture |

| | |
|---|---|
| Name of the Implementing Agency:<br>Signature:<br>Date: | - Land Use Division, Department of Agriculture<br>-<br>-14.11.2023 |

**C. Update on progressive implementation of the project**

**Project Background**

Exporting agricultural crops has been a significant contributor to Myanmar's economy, representing around one-third of the country's total exports. Myanmar, as a member of the ASEAN community, adheres to specific standards for producing agricultural products in line with the goals of the ASEAN Economic Community (AEC). Myanmar has adopted the National Export Strategy in 2015 and has been improving its competitiveness in agri-food export markets through investments to improve access to finance, quality management, trade facilitation and logistics, and trade information and promotion. Ensuring food safety is of utmost importance, and the Department of Agriculture is actively promoting the cultivation of perennials, vegetables, and culinary crops through the implementation of the Good Agricultural Practices (GAP) practices. This strategic initiative aims to enhance Myanmar's agricultural sector's access to international export markets while prioritizing both product safety and environmental integrity, preventing contamination of valuable resources and environment. Pollution of heavy metal, as a result of natural weathering and anthropogenic factors, in soil and water resources is one of the limiting factors for long term sustainable agriculture. The extent and degree of heavy metal contamination around the probable contaminated sources may be varying depending on the capacity of the activities and geochemical al characteristic of the area.

The project has been started with the overall ambition of assessing the contaminating level of cultivated soil and water resources ensuring safety crops production for local consumption and export. In addition, it is expected to increase the awareness of Heavy Metal hazard to policy makers and local people, afterwards, prevention and protection measures could be established.

**Project Objectives**

1. To assess occurrence of heavy metal and its amounts in specific region
2. To share the information of Heavy Metal risk on safety crop production
3. To increase public awareness on heavy metal contamination in resources and policy Recommendation

## Project Team and Work Breakdown

The team was well organized with project director, deputy project director, project coordinator and assistant coordinator, financial assistant and experts for each of the teams such as laboratory, GIS mapping, social survey. The social survey team is tasked with conducting socioeconomic surveys in the designated regions. The laboratory team is responsible for analyzing soil and water samples, as well as interpreting the results and making recommendations based on the data. The GIS mapping team is assigned to collect soil and water samples from the target areas, installing lab result data, and creating maps. Coordinators and assistant coordinators handle logistics to ensure the timely implementation of activities and report on progress. The financial assistant is responsible for verifying and uploading invoices into the financial application on website.

## Project Components/activities

## A.1. Expert Meeting

As mentioned in the proposal, there are (4) times of expert meetings have to be conducted, 3 times have to be done prior to the other activities have been started. The rest one will be conducted at the end of the project, where all the findings will be presented to stakeholders and relevant technicians.

**(1) First Expert meeting**

The first meeting was conducted on 22-Feb-2023 at Hotel Amara, Naypitaw Union Territories. This meeting aims to know how to identify and manage constraints to increase the odds of the project being a success. Total (25) numbers of participants who are the experts from Yezin Agricultural University (YAU), Department of Agricultural Research (DAR), International Cooperation Division (ASEAN) of Department of Planning (DoP), Environmental Conservation Department (ECD), Land Use Division and experts from the private sectors, and the project steering committee members attended (see Annex I for list of participants).

The outputs from the first expert meeting are as follows:

- The objective of the project was revised.
- Selection criteria for project sites are decided.
- Before final selection of project sites, the database of LUD lab will be reviewed and soil and water samples will be taken and analyzed on possible project sites.
- List of heavy metals to be analyzed in the samples are decided.
- Geo-Index analysis will be done for heavy metals assessment.
- Questionnaires for socioeconomic survey are made.

• The right time schedule for soil and water sampling are made to avoid cropping season and weather etc.

**(2) Second Expert Meeting**

The meeting was organized on 28-Feb-2023 at Hotel Amara, Nay Pyi Taw to discuss the implementation plan and pilot project sites. A total of 25 experts from States and Regions, related private sectors, the project steering committee members attended the meeting (see Annex I for list of participants).

The following points are discussed and decided to confirm;

•Mandalay Region, Ayeyarwady Region, Naypyitaw Union Territories and Shan State (south) are selected as the project sites based on the selection criteria.

•Training module and training contents are discussed based on the farmers' prospects.

•Trainees of farmers and staffs should be selected from different location.

•The available date for conducting trainings and socioeconomic survey is set up.

**(3) Third Expert Meeting**

The 3rd expert Meeting was convened on 10-March-2023 at Hotel Amara, Naypyitaw Union Territories to find the constraints that will face in doing this project, seek the advice, guidelines and recommendation from expert on project activities. Director General, Deputy Director General of Department of Agriculture (DoA), Director General of Department of Planning, the experts from Yezin Agricultural University (YAU), Department of Agricultural Research (DAR), International Cooperation Division (ASEAN) of Department of Planning (DoP), Environmental Conservation Department (ECD), Department of Technology, Department of Technology Promotion and Coordination and experts from the related private sectors, and the project steering committee members attended the meeting. The total (30) participants attended, and the following points are decided to accomplish the project (see Annex I for list of participants).

• Kyaunggon Township are selected as project site in Ayeyarwady Region and the socioeconomic survey focus to the irrigated area (rice-pulses) in which soil and water sampling will be done.

• In Naypyitaw Union Territories, the irrigated areas especially for vegetables such as Nwe Yit, Kyar Thay Ayi and Yway Su village are selected as preliminary target sites.

• In Mandalay Region, Amarapura Township and Bwat and Indine village in Yamethin Townships are targeted as preliminary project sites.

• In Shan State, Heho and Kalaw Townships are chosen as preliminary project sites.

• Arsenic, Lead, Nickel, Chromium, Cobolt and Mercury are going to assay as preliminary elements and final list of heavy metals will be decided based on these results.

• Sampling methods were discussed and decided.

## A.2 Baseline Survey

**Site selection, sampling design and procedure of baseline survey**

This project work mainly focused on the assessment of heavy metals in soil and water supply source for crop cultivation. Four townships (Kyuanggon Township, Ayeyarwady Region; Tatkon Township, Nay Pyi Taw Union Territories; Kyaukse, Mandalay Region; and Kalaw Township, Shan State) were selected as the project area based on the literature review, Land Use Division soil and water analysis database and area which was the long-term excessive use of agrochemicals for vegetable production and area near the discharge of mining and textile production.

**Sampling design of baseline survey**

Purposive sampling was designed to choose the target survey area at regional and township level and a simple random sampling was applied to conduct the household survey in the selected townships. Out of the four survey areas, base line survey for Ayeyarwady region and Nay Pyi Taw region has started in March and May 2023 to provide baseline information prior to soil and water samples collection for analysis and mapping.

Ayeyarwady region has 8 districts, 26 townships, 45 towns, 302 wards, 1920 village tracts and 11860 villages. Refer to the previous lab database of heavy metal contamination; two townships, Kyaunggon and Ye Kyi townships were purposively selected for field survey. One hundred and ninety households were randomly selected from 8 village tracts from Kyaunggon and 8 village tracts from Ye Kyi Townships.

Nay Pyi Taw region has 4 districts, 8 townships, 302 wards, 187 village tracts and 803 villages. Refer to the previous lab database of GAP crops inspection and discussion with district level extension staff; two townships, Tatkon and Lewe townships were purposively selected for field survey. One hundred and ninety five households were randomly selected from 5 village tracts from Lewe and 3 village tracts from Tatkon Townships.

**Sample size of baseline survey**

In Ayeyarwady region, total sample size of 190 households was drawn in a two-stage sampling process from 16 village tracts chosen with probability proportional to their number of households. Ninety-five households were randomly selected from each Township (56 households as a control and 39 households as a target in Kyaunggon) and (70 households as a control and 25 households as a target in Kyaunggon). Likewise, total sample size of 190 households was drawn in a two-stage sampling process from 8 village tracts chosen with probability proportional to their number of households in Nay Pyi Taw region. Ninety-five households (60 households as a control) and

(35 households as a target) were randomly selected from each township, Tatkon and Lewe, respectively.

An average of 10-20 households per village tract were interviewed using a semi-structured questionnaire. Sample size was calculated based on the formula (Yamane, 1967) at 95 % confidence interval and 10 % precision level.

$n = N / (1+N (e)^2)$

Where,

n = Total number of sample size

N = Total number of households in the village tract

e = precision (e.g. +/- 5%, or +/- 10%)

| Area | Townships | Village tracts | Total Farm Households | Minimum Sample | Target | Control |
|---|---|---|---|---|---|---|
| Ayeyarwady | Kyaung Kone | 8 | 1953 | 95 | 39 | 56 |
| Ayeyarwady | Ye Kyi | 8 | 1974 | 95 | 25 | 70 |
| Total | | 16 | 3927 | 190 | 64 | 126 |
| Nay Pyi Taw | Tatkon | 3 | 1466 | 95 | 35 | 60 |
| Nay Pyi Taw | Lewe | 5 | 2006 | 95 | 35 | 60 |
| Total | | 8 | 3472 | 190 | 70 | 120 |

**Data collection of baseline survey**

Rice production, rainfall pattern, land utilization, sources of irrigation, sowing acres growing with GAP, kinds of crops, awareness of heavy metal contamination were collected from the various sources of Departments. Township and village profile were documented through key informant interviews with village tract leaders. For household survey, a semi-structured questionnaire was prepared based on the outcomes of expert meeting and information provided from key informant interviews. Information about sources of water for crop production, heavy metal contamination in soil and water and traditional remedial measures, prior notice or precautions from Department of Public Health to protect the harmful affect to human health was discussed through open questions by means of focus group discussions (FGD) and key informant interviews (KI).

Household questionnaire survey was conducted through face-to-face interview. A team of socio-economic survey composed of local extension staff from DOA office of Kyaunggon and Ye Kyi Townships in Ayeyarwady region and Tatkon and Lewe Townships were trained as enumerators to conduct the survey. A semi-structured questionnaire was set up with following contents to know their demographic variables, livelihood pattern and income sources, crop production

practices, cropping pattern, kinds and amount of agro chemicals (fertilizers, pesticides and weedicide), awareness of heavy metal contamination.

## A.3 Soil Sampling, Analyzing, Data Installation into map

### 1. Soil Sampling

### 1.1 Description of Targeted Area

Some Townships in different States and Regions, where heavy metal pollution may exit based on the results of the research work done by related Ministries such as Ministry of Science and Technology, Ministry of Environmental Conservation and Forestry, Ministry of Health, and unpublished data of Land Use Division, were listed and identified as a preliminary survey area. Soil and water samples were collected and analyzed the content of heavy metals before selecting the project area. According to the analyzed results, Kyaunggon Township, Ayeyarwaddy Region and Tatkon Township in Naypyitaw Union Territories was selected as the first and second target area for this project, respectively.

**Kyaunggon Township**

Kyaunggon Township located in Pathein District, Ayeyarwady Delta Region, of southern Myanmar, is one of the main rice production areas of the country. It is situated between Latitude 17º 5′ 45″ North and longitude 95º 9′ 45″ East. The survey township covers a total area of 68062 hectare. The mean annual rainfall is 88.57 inches (2250 mm) with the average annual raining days are 113 days. Kyaunggon Township has a tropical monsoon climate, with normal temperatures ranging from the lowest 16.1°C to the highest 38.2°C.

The main cropping patterns are rice-rice and rice-pulses and rice, pulses, maize and chili are major crops that are grown in this area. Rice and pulses are growing about 54% and 46% of the total cultivated area, respectively. Rain-fed rice is mainly cultivated in flooded land area and summer rice is cultivated with channel and river pumped irrigation. Pumped irrigation from some creeks, rivers, and tube well water is the main source of water supply for crop cultivation in this township. About 97% of net cultivated area is lowland and the remaining 3% is grown the horticultural crops. As for the soil types of agricultural areas in Kyaunggon Township, it is mostly Brown Meadow Slightly Gley Soils, Meadow Gley Soils, and some Brown Meadow Soils, Light Brown Meadow Soils and then in deep water land Meadow Gley Swampy Soils are found. Soil texture is mostly Clay, and Clay Loam is also found.

**Tatkon Township**

The Tatkon township, second target survey area, is located in Ottarathiri district, Naypyitaw Union Territories Area, Central part of Myanmar. It is situated between latitude 19º 55′ and 20º

21′ North, and longitude 95º 20′ and 96º 30′ East. The target survey area of Tatkon township covers a total area of 100,210 hectare. The mean annual rainfall is 35.17 inches (893.32 mm) with the average annual raining days are 76 days. Tatkon township has a hot and humid weather with normal temperatures ranging from the lowest 23.61°C to the highest 41.4°C.

The major crops are rice, groundnut, sesame, pulses, sunflower, cotton, seed corn and some culinary crops such as onion, chili and vegetables. The main cropping pattern is rice-pulses in lowland area and rice-corn in upland area. About 52% of net cultivated area of the township is upland area and 48% is lowland cultivated area. Different channels from Sin They Reservoir are the main sources of irrigation used for summer rice cultivation and tube well water is mainly used for upland crop cultivation. The soil types of agricultural area are Meadow Alluvial Soils, Brown Meadow Soils, Yellow Brown & Light-Yellow Brown Forest Soils, and Gravelly Red Brown Savanna Soils. The soil textural classes found in this area are mostly Sandy Clay Loam, Sandy Loam, Clay, and Clayey Sand.

**1.2. Soil and Water Sampling Methods**

A preliminary field survey of the actual ground condition was conducted in order to collect soil samples in Kyaunggon Township and Tatkon Township. Some necessary information such as digitized maps and secondary data of the targeted townships were collected and then checked the topography using Digital Elevation Model (DEM).

Soil samples were collected at 20 cm depth. Soil samples were air-dried at room temperature and sieved using a 2 mm mesh sieved. The samples were stored in high-density polyethylene bags to prevent contamination. Water samples were taken from the tube well, irrigation canal by direct pumping with motor engine after 1 hour later and the collected samples were stored in polyethylene bottles. A total of 358 soil samples and 23 water samples from Kyaunggon Township and 184 soil samples and 16 water samples from Tatkon Township were collected.

The kobo data collection system was used for collection of the sampling data of the soil and water samples such as sampling code number, sampled date, village name & village tract, location, cropping pattern, current crops, fertilizer application, and some information of sources which caused heavy metals contamination. Location of soil and water sampling points of the Kyaunggon Township was illustrated in Figure (1-a) and (1-b) and for Tatkon Township was illustrated in Figure (2-a) and (2-b). The samples collected were labelled and transported to the laboratory for heavy metal analysis.

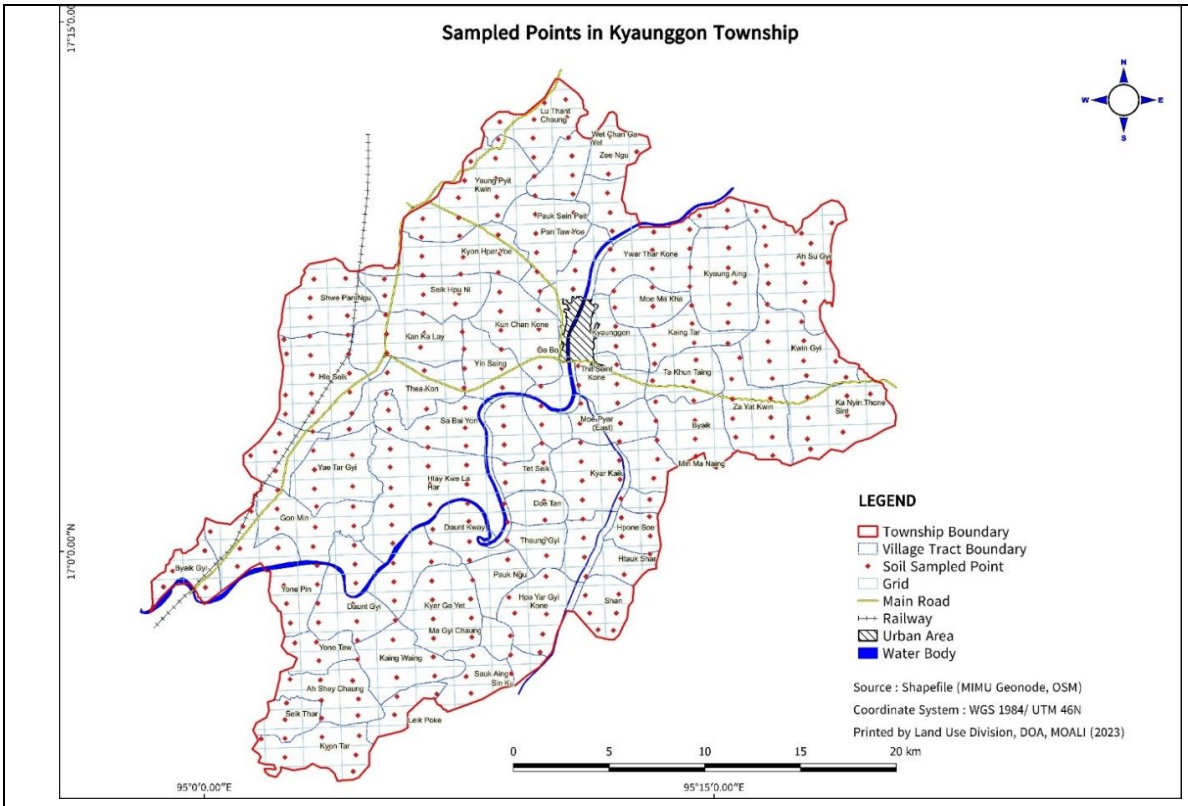


Figure (1-a). Location of soil sampling points in Kyaunggon Township

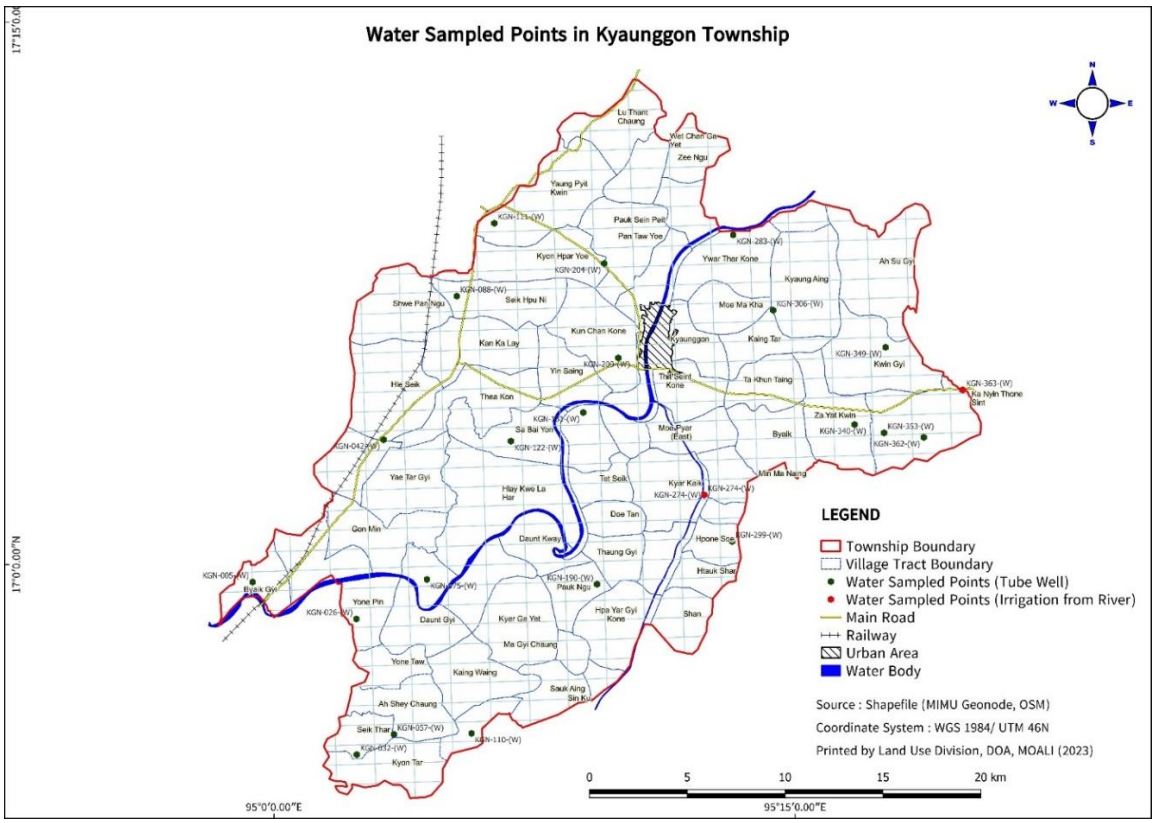


Figure (1-b). Location of water sampling points in Kyaunggon Township

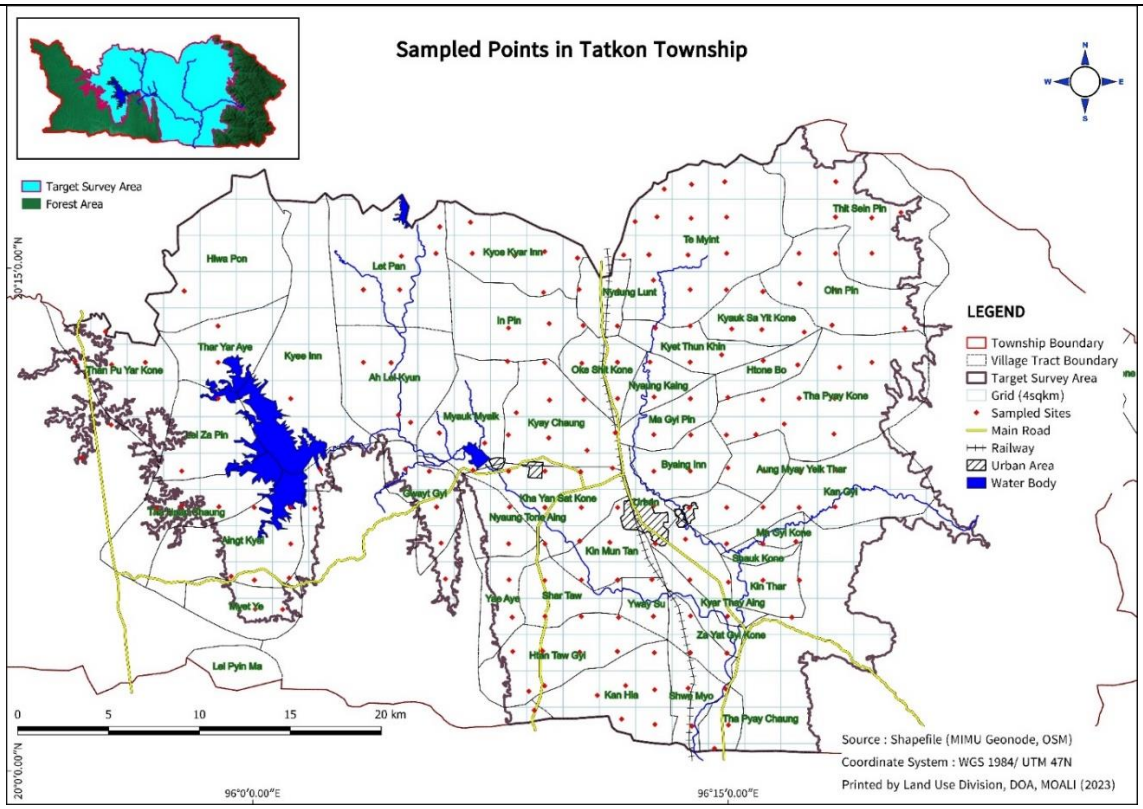


Figure (2-a). Location of soil sampling points in Tatkon Township

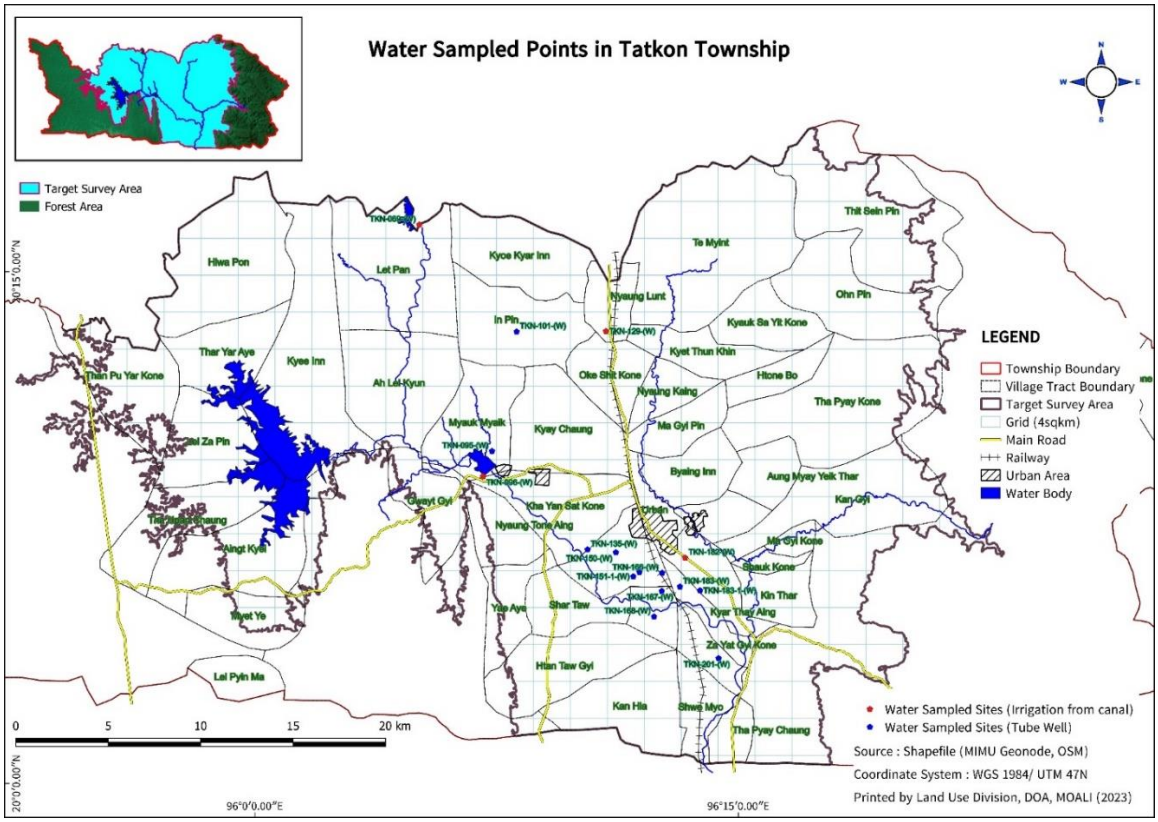


Figure (2-b). Location of water sampling points in Takkon Township

**(2) Soil and Water Analyzing at the Laboratory**

The samples were homogenized to determine selected heavy metals (arsenic (As), cadmium (Cd), chromium (Cr), nickel (Ni), and lead (Pb)) by Atomic Absorption Spectrophotometer (Agilent Technologies GTA 120 Graphite Tube Atomizer and 200 Series AA) using standard digestion procedure as reported in the literature (Dai, 2004). All samples were analyzed for reasons of quality control, several blanks and three internal standards were used during procedure. Samples were analyzed three times and the mean values were recorded for statistical purposes and comparison. Arsenic will be measured later end of this year due to failure in AAS graphite components.

**2.1 Data analysis and statistical analysis**

The laboratory test results of all parameters were subjected to Descriptive Statistics and bivariate variation using Microsoft Excel 2019.

(a) Pollution risk assessment

(b) Single pollution index

As the pollution index, Index of geo-accumulation (Igeo), Metal Contamination factor (CF) and Potential ecological hazard index (Er) method were used to access the pollution impact.

The Igeo was computed using the following equation (Muller, 1979).

$Igeo = \log2 (Cn/1.5 \times Bn)$

Where Cn is the measured concentration of heavy metals in soil and Bn is the reference values expressed here as worldwide soils average (As = 5, Cd = 0.5, Cr = 54, Ni = 68 and Pb = 25) Kabata-pendias and Mukherjee (2007), Turekian, K.K. and Wedepohl, K.H. (1961). The constant 1.5 is used for the possible variation of the background data due to the lithogenic effects.

The CF is computed using the following equation (Hakason 1980).

$CF = Cs/ Co$

Where Cs is the concentration of metal in the studied sample and Co is baseline concentration (mean worldwide soils).

The Er of a given contaminant was suggested by Hakanson (1980) as follows:

$Br = Tr \times CF$

where CF is contamination factor and the Tr is toxic-response factor for a given metals; As = 10, Cd = 30, Cr = 2, Ni = 5 and Pb = 5 (Hakanson, 1980 & Zhang C.J, 2008).

Each index was ranked into several classes as shown in (Table 1).

**Table 1: Igeo, CF and Er classes**

| Index Type | Value | Environmental Risk Grade | Reference |
|---|---|---|---|
| $I_{geo}$ | $I_{geo} \leq 0$ | Practically uncontaminated | Muller 1979) |
| | $0 < I_{geo} \leq 1$ | Uncontaminated to moderately contaminated | |
| | $1 < I_{geo} \leq 2$ | Moderately contaminated | |
| | $2 < I_{geo} \leq 3$ | Moderately to heavily contaminated | |
| | $3 < I_{geo} \leq 4$ | Heavily contaminated | |
| | $4 < I_{geo} \leq 5$ | Heavily to extremely contaminated | |
| | $I_{geo} > 5$ | Extremely contaminated | |
| CF | $CF < 1$ | Low contamination | Hakanson (1980) |
| | $1 \leq CF < 3$ | Moderate contamination | |
| | $3 \leq CF < 6$ | Considerable contamination | |
| | $CF \geq 6$ | High contamination | |
| Er | $Er < 40$ | Low potential ecological risk | Hakanson (1980) |
| | $40 \leq Er < 80$ | Moderate potential ecological risk | |
| | $80 \leq Er < 160$ | Considerable potential ecological risk | |
| | $160 \leq Er < 320$ | High potential ecological risk | |
| | $Er \geq 320$ | Very high ecological risk | |

**(3) Generating the spatial distribution maps**

The spatial distribution maps of heavy metals such as Cd, Cr, Ni and Pb were generated using the inverse distance weighted (IDW) interpolation method based on the analytical results of each heavy metal concentration. The IDW was performed by Quantum Geographic Information System (QGIS) software version 3.28.6, with a 358 data points for Kyaunggon Township and 184 data points for Tatkon Township to interpolate heavy metal concentration.

### 3.1 Results and discussion

**Heavy metal concentration of soil samples**

Descriptive statistics results (minimum, maximum, mean, standard deviation) for each heavy metal of 358 soil samples in Kyaunggon Township and 184 soil samples in Tatkon Township at the depth of 0-20 cm were presented in Table 2.

**Table 2: Descriptive statistics of analyzed Heavy Metals**

| Township | Metals (mg/kg) | Mean | Min | Max | Standard Deviation (SD) |
|---|---|---|---|---|---|
| Kyaunggon | Cd | 0.021 | 0.00 | 0.400 | 0.029 |
| | Cr | 0.155 | 0.00 | 1.716 | 0.424 |
| | Ni | 2.291 | 0.096 | 16.522 | 2.340 |
| | Pb | 1.443 | 0.10 | 5.000 | 0.828 |
| Tatkon | Cd | 0.012 | 0.00 | 0.070 | 0.013 |
| | Cr | 0.0006 | 0.00 | 0.030 | 0.0032 |
| | Ni | 0.504 | 0.00 | 6.804 | 0.722 |
| | Pb | 0.746 | 0.00 | 6.560 | 0.862 |

A trend was found in Kyaunggon Township for the concentration of Ni to be highest followed by Pb, Cr and Cd. The distribution of detected concentration of heavy metals showed a trend of Pb > Ni > Cd > Cr in Tatkon Township.

**Cadmium**

Cadmium (Cd) is a non-essential and toxic heavy metal (Sholoha and Kalshetty, 2017) and it has been found in relatively high amounts in common P fertilizers which is obtained from sediments (Nino-Savala et al., 2019). Since this metal generally poses a high risk for soil fertility, crop cultivation and plant, analysis of Cd content in the collected soil samples are done in this research work.

The spatial distribution of Cd concentration in Kyaunggon Township and Tatkon Township are shown in Figure (3-a) and (3- b). The observed concentration of Cd in the collected soil samples was 0.002 to 0.4 mg/kg with a mean value of 0.021 mg/kg in Kyaunggon Township (Table 2). It was shown that any Cd was detected in about 30% of total samples. The relatively high Cd concentration of 0.4 mg/kg was only observed in the north-eastern part of this township area.

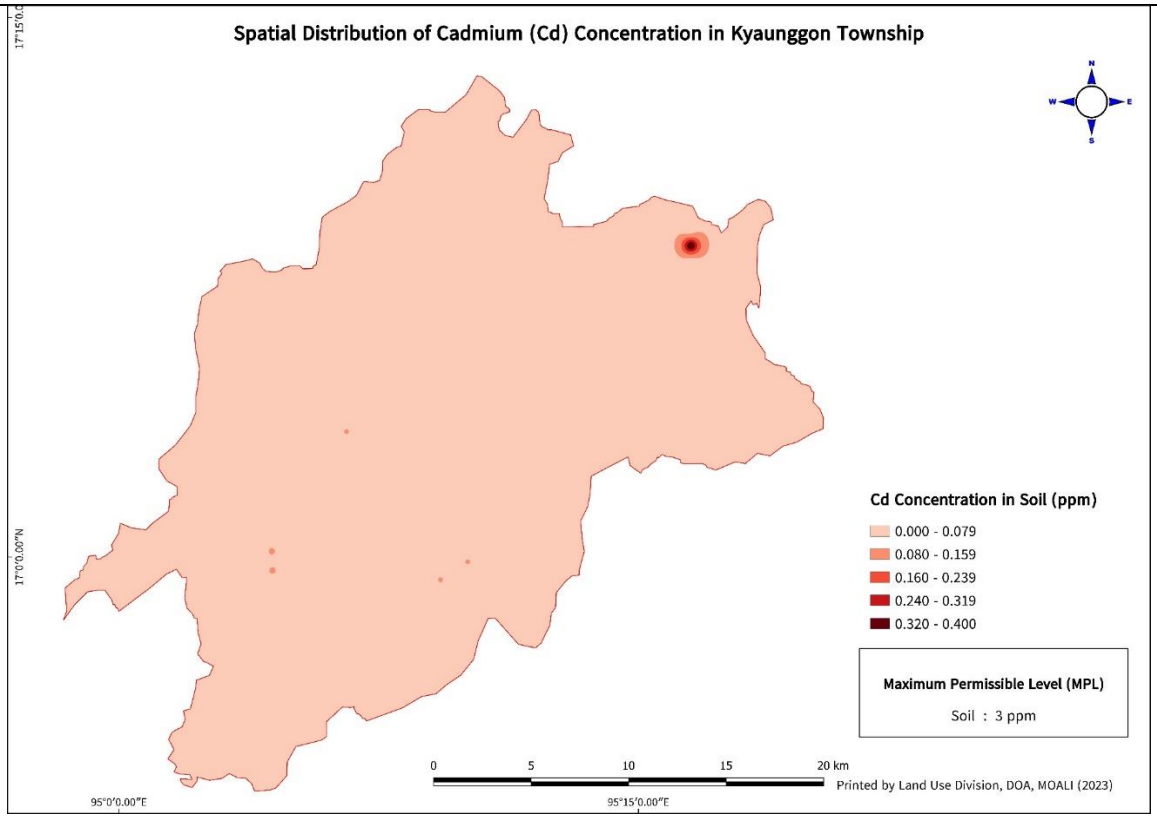


Figure (3-a). Spatial distribution of Cadmium (Cr) concentration in soil of Kyaunggon Township

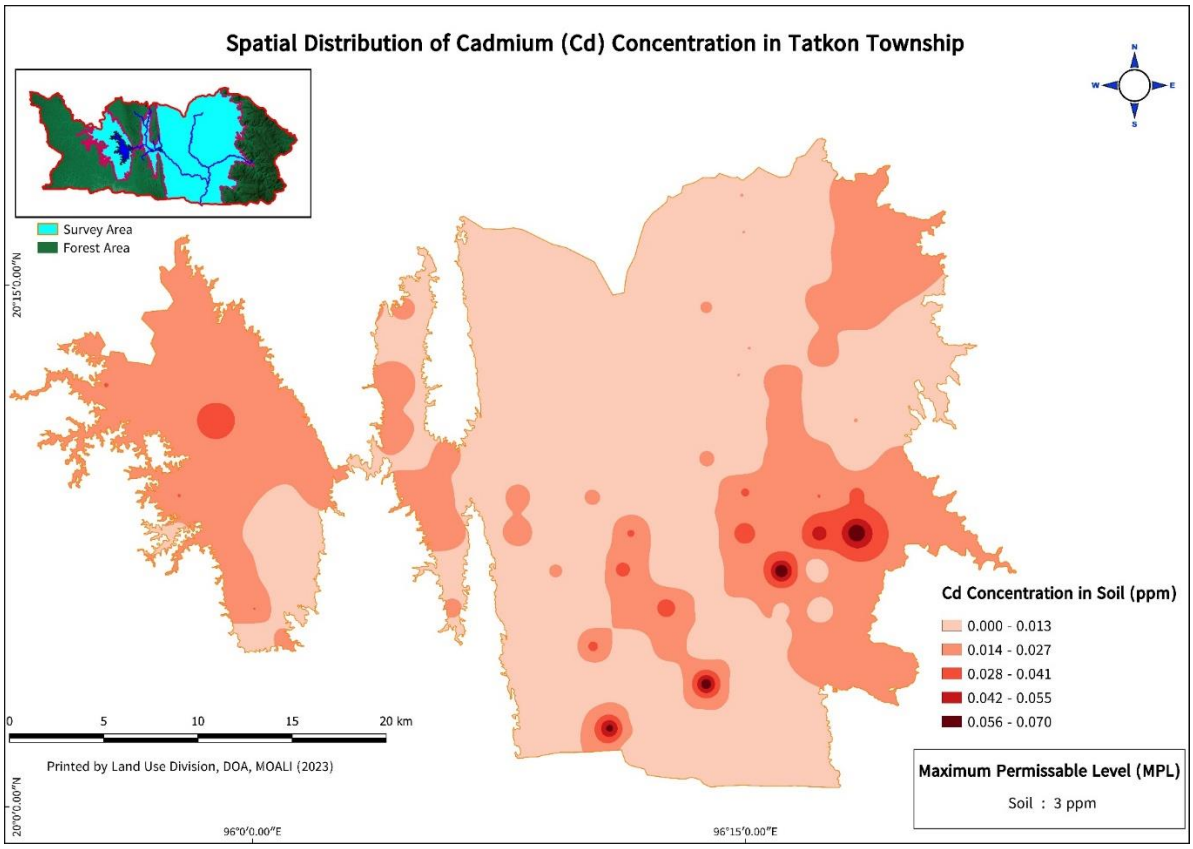


Figure (3-b). Spatial distribution of Cadmium (Cd) concentration in soil of Tatkon Township

In Tatkon Township, Cd was undetected in about 22% of collected soil samples (Table 2). The minimum detected value of Cadmium is 0.001 mg/kg and a maximum 0.07 mg/kg-with a mean value of 0.012 mg/kg of concentration. The elevated concentrations are observed in some village of the south-east parts of this township. In both target sites, the Cd content is lower than that in a major placer gold mining area in Sagaing Region of Myanmar (3.07 mg/kg) reported by Tun et al. (2022).

There was a significant difference ($P<0.001$) on the concentration of Cd between two study sites. The collected soil samples had about 75% higher Cd content in Kyaunggon Township than that in Tatkon Township. This might be due to the fact that high usage of herbicides which can result in high Cd content in the agricultural soils in Kyaunggon Township since the number of farmers using herbicides increased significantly in the dry season paddy cultivation within 10 years of period from 2006 to 2016 in Ayeyarwady Region (Cho et al., 2017) while in Tatkon Township, the Central Dry Zone region where majority of the farmers practiced mechanical hand weeding instead of herbicide (Maung et al., 2018). Suciu et al. (2022) stated that the presence of Cd in soil depends largely on the use of P fertilizers. The use of P fertilizer such as TSP in Delta Region were about 52% higher than that in Dry Region of Myanmar (IFPRI, 2021). Thus, this may contribute higher content of Cd in Kyuanggon Township than that in Tatkon Township.

**Chromium**

Yang et al. (2018) and Fallahzadeh et al. (2018) stated that the amount of chromium (Cr) released into the environment globally in the past 50 years has been estimated more than 30,000 tons, majorly accumulated in industrial and agricultural soils. Cr pollutants accumulate constantly in the soil, resulting severe soil Cr pollution problems due to the rapid development of industry (Xu et al., 2023). Agricultural soil is a basic medium for human survival and pollution of agricultural soil with heavy metals can affect indirectly human health and safety (Fallahzadeh et al., 2017, 2018). For this reason, Cr is selected to analyze its amount in the collected samples.

The spatial distribution and classified map of Cr concentration in Kyuanggon Township and Tatkon Township generated using Inverse Distance Weighting (IDW) interpolation technique which were displayed in Figure (4-a) and (4-b). According to detected results, majority of the soil samples (83%) has no Cr content and only 17% of the total samples has Cr with the values from 0.004 to 1.716 mg/kg and the mean of 0.155 mg/kg in Kyaunggon Township (Table 2). The spatial distribution for Cr showed that the highest concentrations were mostly occurred in the south western part of this Township.

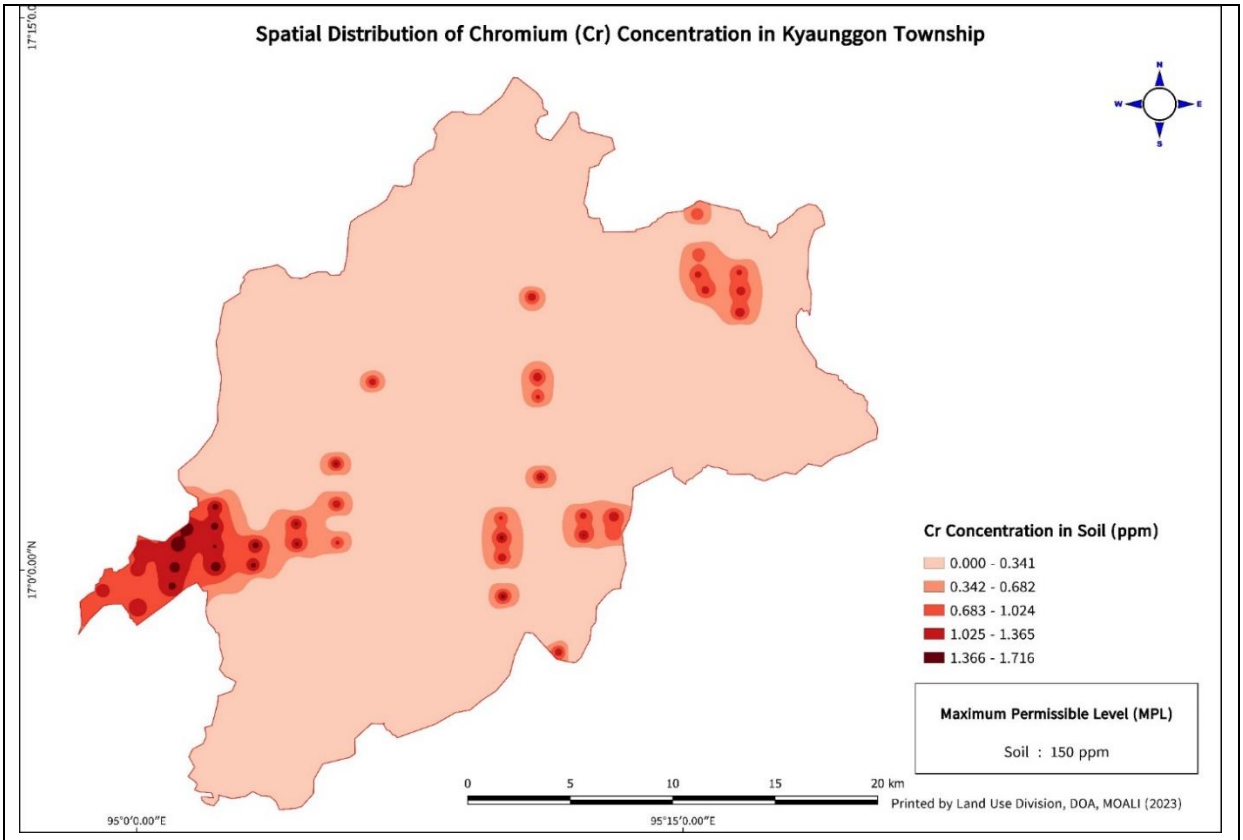


Figure (4-a). Spatial distribution of Chromium (Cr) concentration in soil of Kyaunggon Township

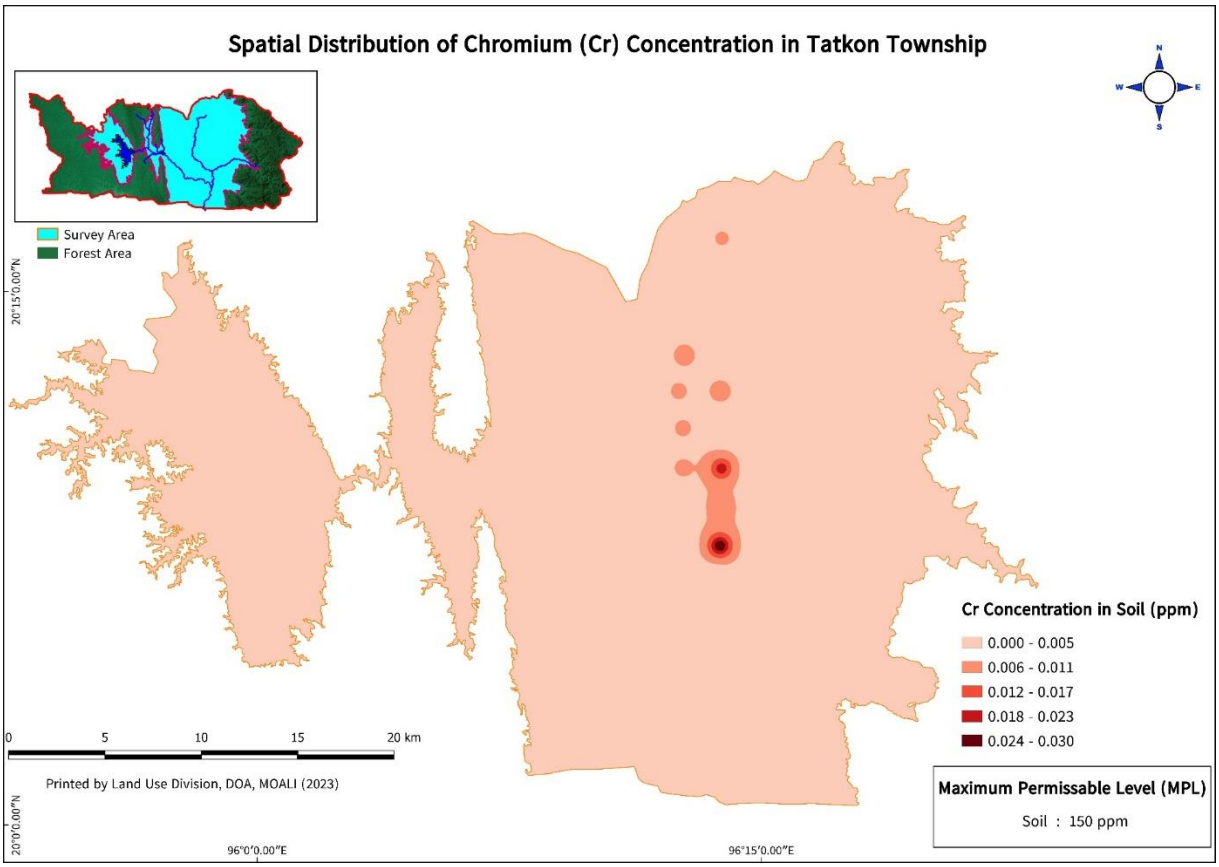


Figure (4-b). Spatial distribution of Chromium (Cr) concentration in soil of Tatkon Township

In Tatkon Township, most soil samples (93%) had no Cr content and only 7% of the soil samples showed Cr concentration with the values from 0.002 to 0.03 mg/kg and mean value was 0.0006 mg/kg (Table 3). The higher concentrations of Cr were found in the flat plain of middle-east part of this Township. The collected soil samples of Kyaunggon Township had a significantly higher Cr value ($P<0.001$) than that in Tatkon Township.

**Nickel**

Nickel (Ni) is one of the heavy metal elements widespread distributions in the environment and Ni contamination imposes negative effects on the stability of soil ecosystem (Zhang et al., 2022). Agrochemical containing Ni can lead to the toxicity of Ni which affect the plant nutrient absorption and sever health problems for animals and human (Bashir et al., 2020). Therefore, Ni in agricultural soils was selected to be analyzed in the study area.

The observed concentration range of this metal in Kyaunggon Township and Tatkon Township was shown in spatial distribution pattern by Figure (5-a) and (5-b). It was observed that the mean concentration of Ni was 2.291 mg/kg and 0.504 mg/kg in Kyaunggon and Tatkon Township respectively (Table 2), which was lower than that of global range of Ni (2 to 750 mg/kg) in agricultural soil (Umer et al., 2021). The highest Ni concentration was found in the middle part of Kyaunggon Township, near the west bank of the Darka River (Kyaunggon River) and in the east and north-eastern part of the area. Result showed that the highest level of Ni concentration was found in Kin Mun Tan village tract, near Tatkon Township, urban area. The similar trend has found in Kyaunggon Township however, the amount of Ni value is higher than in that in Tatkon Township.

**Lead**

In the past five decades, lead exposure was estimated to account for 800,000 tons into the environment globally, that has much accumulated in soil resulting in serious levels of population (Chen et al., 2016). Orellana et al. (2019) reported that agricultural soils irrigated with contaminated water from metallurgical mining activities for more than 70 years can contribute to an environmental pollution and impact on food safety and human health. Based on unpublished data of Land Use Division lab analysis data, lead contamination of soil in the neighborhood of mining areas has been found in countries like Myanmar. Prior to the 1940s lead is found throughout Myanmar due to large mining activities and further mine development (Mac Tavish et al., 2018). However, there is limited research evidence related to the level of environmental pollution of Pb in agricultural soil and irrigation water in Myanmar. Accordingly, lead in the collected samples was analyzed.

Figure (6-a) and (6-b) showed the spatial distribution of Pb concentration in Kyaunggon Township and Tatkon Township. Higher Pb concentrations in soil samples were found in north-

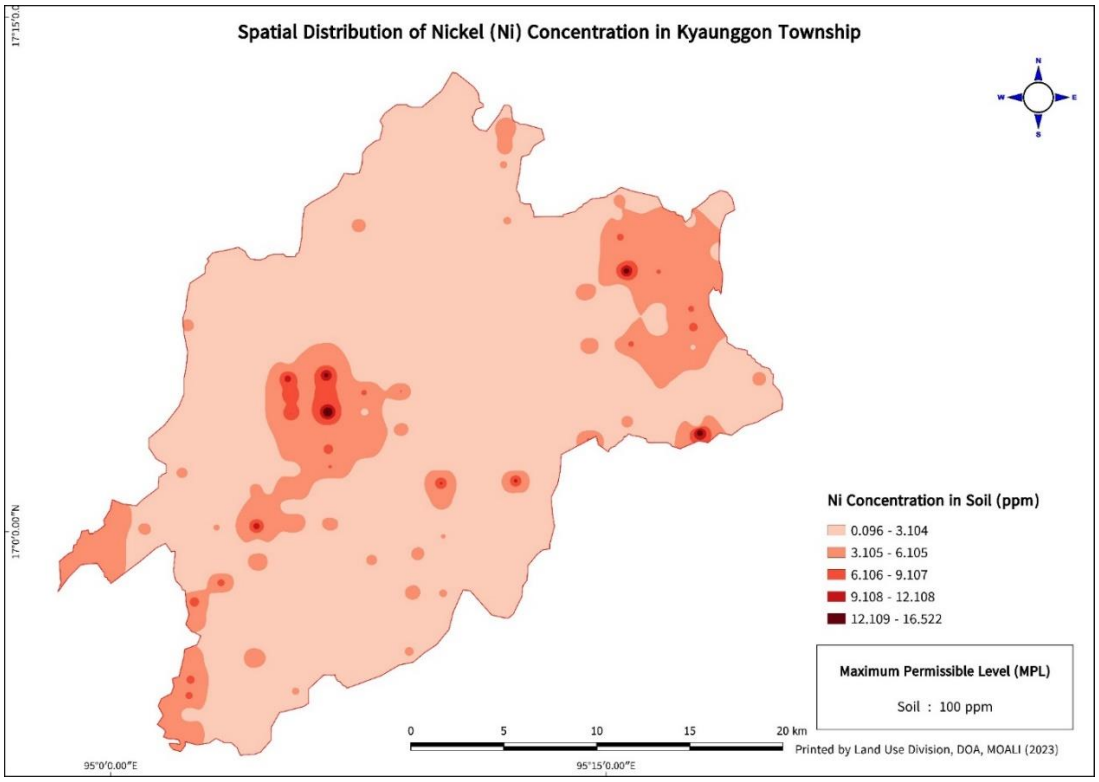


Figure (5-a). Spatial distribution of Nickel (Ni) concentration in soil of Kyaunggon Township

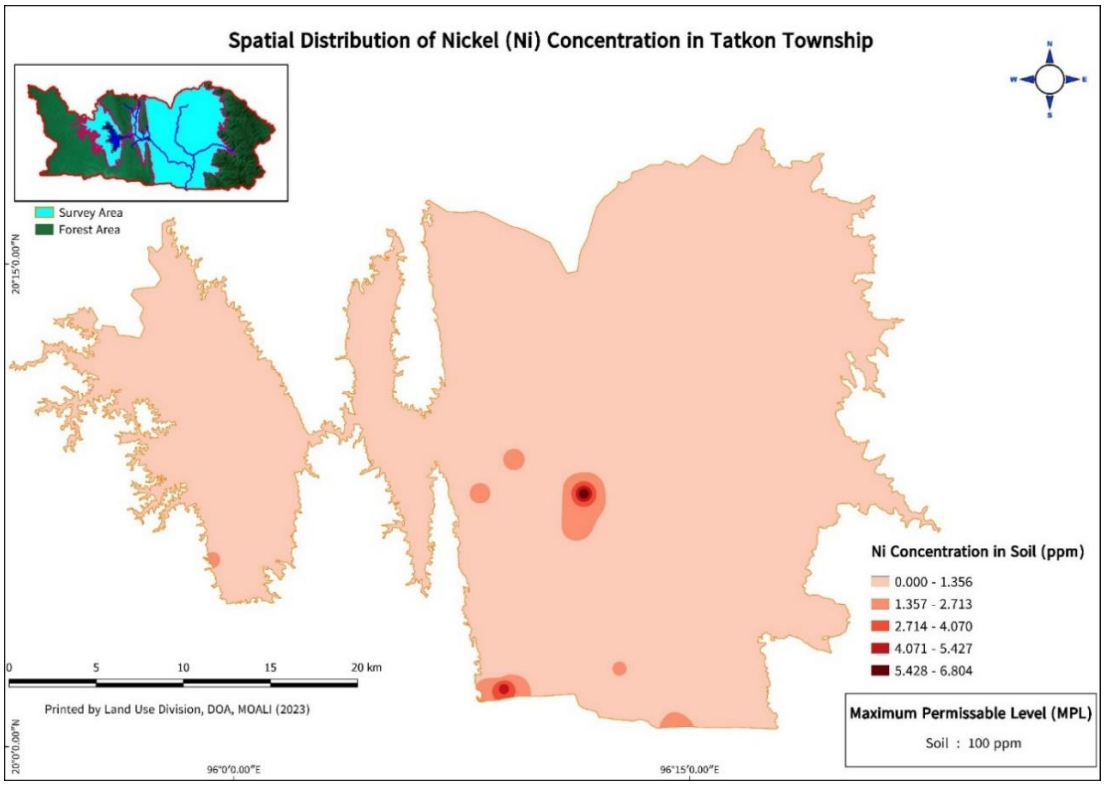


Figure (5-b). Spatial distribution of Nickel (Ni) concentration in soil of Tatkon Township

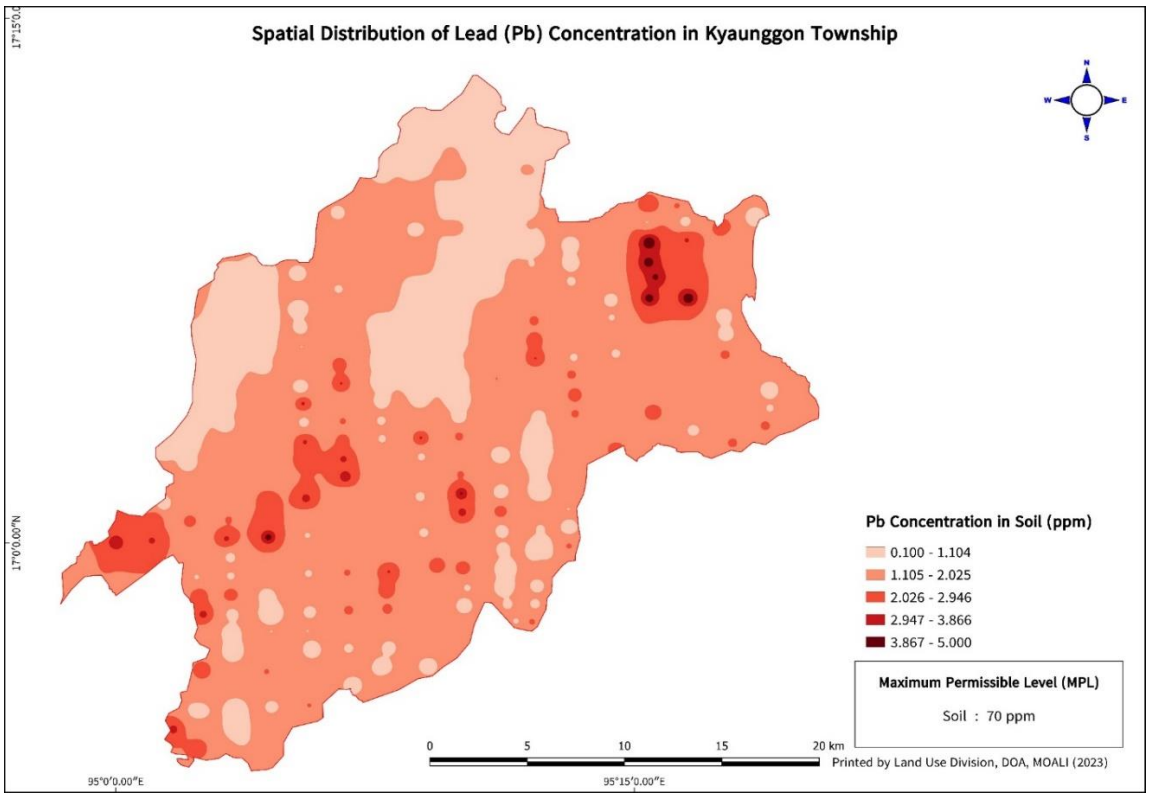


Figure (6-a). Spatial distribution of Lead (Pb) concentration in soil of Kyaunggon Township

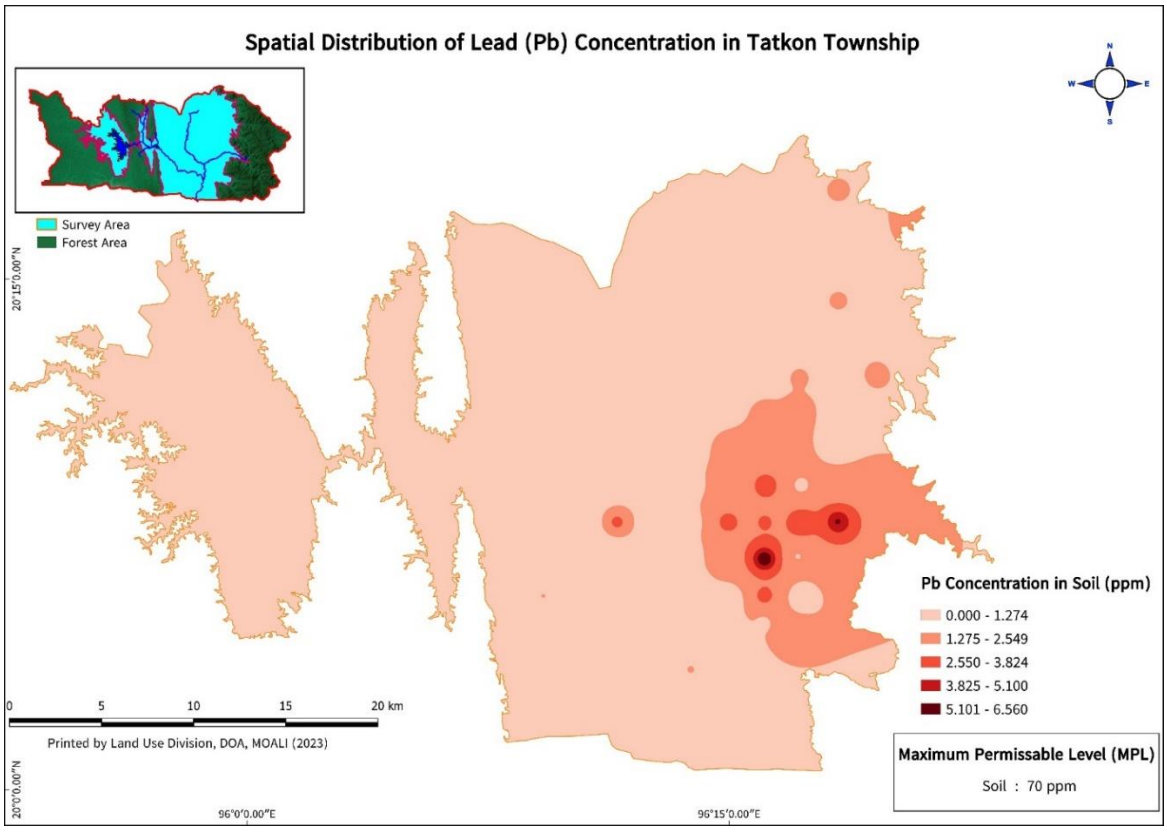


Figure (6-b). Spatial distribution of Lead (Pb) concentration in soil of Tatkon Township

eastern and south-western part of Kyaunggon Township and south-eastern part of Tatkon Township. An average value of lead was 1.443 mg/kg and 0.746 mg/kg respectively (Table 2). Like to the detected results of Cd, Cr and Ni elements, Pb content in Kyaunggon was double than that in Tatkon Township.

Although absolute values of heavy metal concentrations are important especially during remediation efforts, these values do not consider the relative toxicity of the individual heavy metals in the study sites. Ji et al. (2012) stated that the values of Maximum Permissible Limit (MPL) must be taken into consideration for the assessment of heavy metal pollution in soils. In this study the soil MPL set by the FAO are considered to compare the concentration of heavy metals of collected soil samples in Kyaunggon Township (KG) and Tatkon Township (TK) shown in Figure (7).

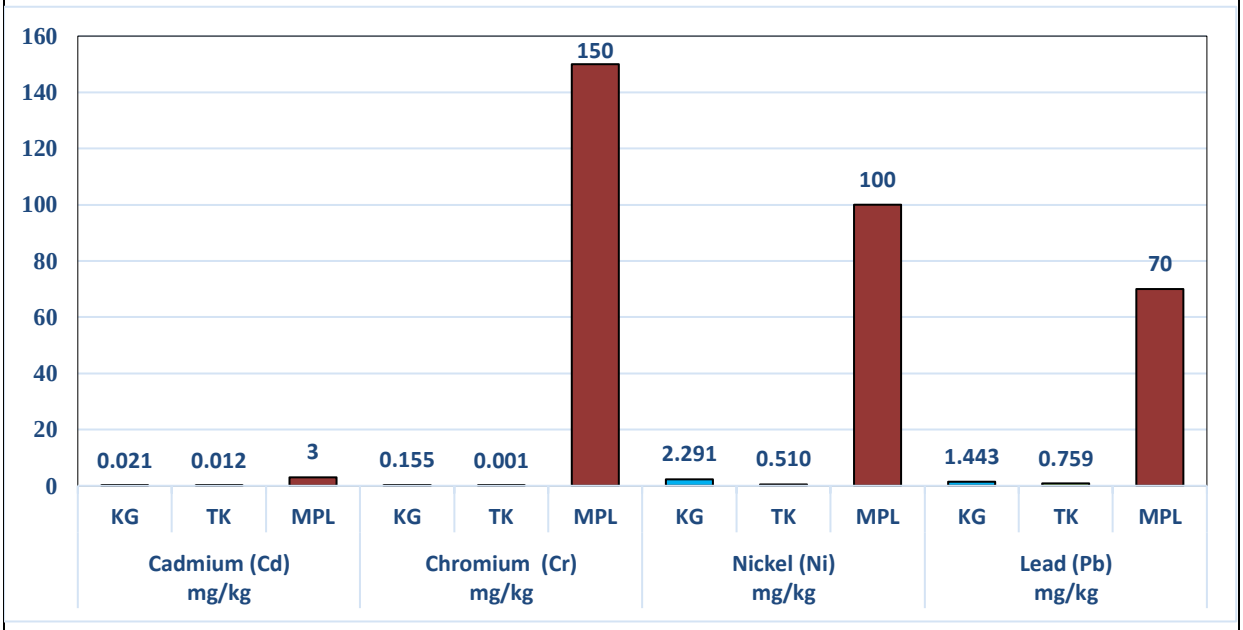


Figure - 7: Comparison of heavy metal levels with the FAO standard Maximum Permissible Limit (MPL)

According to the FAO standard, the MPL for total concentrations of Cd, Cr, Ni, and Pb in the soil are 3mg/kg, 150mg/kg, 100mg/kg and 70mg/kg, respectively. It was observed that the levels of analyzed Cd, Cr, Ni and Pb did not exceed that of the FAO standard MPL limits. Kwee and Soe (2021) also found that the concentration of Cr and Pb in tea and apple growing area of Chin State, Myanmar, were below the MPL. Results of this study indicated that there is no risk of heavy metals in cultivated soil of both study sites.

**Pollution risk assessment**

The estimation of the overall contamination of investigated soils in both study sites was assessed using single indices; geoaccumulation index (Igeo), contamination factor (CF) and ecological risk (Er) factor. The summary statistics of calculated Igeo, CF and Er) factor for the heavy metals Cr, Cd, N and Pb in both studies area is shown in Table (3) and Table (4). The calculated Igeo index values of Cr, Cu, Ni and Pb for the soil samples in both study Townships are less than 1. These findings agree with the previous study of Sann and Phyo (2018) where the Igeo index value of Cr and Pb were less than zero in agricultural soils of Central Dry Zone in Myanmar.

**Table 3: Summary statistics of Igeo, CF, Er in Kyaunggon Township**

| Parameter | $I_{geo}$ | | | | CF | | | | Er | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cd | Cr | Ni | Pb | Cd | Cr | Ni | Pb | Cd | Cr | Ni | Pb |
| Mean | -3.075 | -1.295 | -6.115 | -4.934 | 0.01 | 0.004 | 0.115 | 0.072 | 0.313 | 0.009 | 0.458 | 0.361 |
| Median | -3.529 | 0 | -5.979 | -4.918 | 0.008 | 0 | 0.081 | 0.062 | 0.24 | 0 | 0.323 | 0.310 |
| Mode | 0 | 0 | -8.499 | -5.349 | 0 | 0 | 0.014 | 0.046 | 0 | 0 | 0.056 | 0.230 |
| SD | 2.292 | 3.051 | 1.416 | 0.863 | 0.015 | 0.012 | 0.117 | 0.041 | 0.436 | 0.024 | 0.468 | 0.207 |
| Range | 7.814 | 14.306 | 7.427 | 5.644 | 0.2 | 0.049 | 0.821 | 0.245 | 6.0 | 0.098 | 3.285 | 1.225 |
| Minimum | -7.814 | -14.31 | -10.05 | -8.551 | 0 | 0 | 0.005 | 0.005 | 0 | 0 | 0.019 | 0.025 |
| Maximum | 0 | 0 | -2.626 | -2.907 | 0.2 | 0.049 | 0.826 | 0.25 | 6 | 0.098 | 3.304 | 1.250 |

**Table 4: Summary statistics of Igeo, CF, Er in Tatkon Township**

| Parameter | *Igeo* | | | | CF | | | | Er | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cd | Cr | Ni | Pb | Cd | Cr | Ni | Pb | Cd | Cr | Ni | Pb |
| Mean | -4.12 | -0.881 | -8.180 | -5.577 | 0.006 | 0.00002 | 0.025 | 0.038 | 0.186 | 0.00004 | 0.102 | 0.190 |
| Median | -4.64 | 0 | -8.187 | -5.918 | 0.005 | 0 | 0.017 | 0.029 | 0.15 | 0 | 0.066 | 0.145 |
| Mode | 0 | 0 | -9.263 | 0 | 0 | 0 | 0.008 | 0 | 0 | 0 | 0.033 | 0 |
| SD | 2.46 | 3.328 | 1.972 | 2.054 | 0.007 | 0.00009 | 0.036 | 0.043 | 0.197 | 0.00019 | 0.145 | 0.216 |
| Range | 8.55 | 15.306 | 14.638 | 10.873 | 0.035 | 0.00086 | 0.34 | 0.328 | 1.05 | 0.00171 | 1.361 | 1.640 |
| Minimum | -8.55 | -15.31 | -14.64 | -10.87 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum | 0 | 0 | 0 | 0 | 0.035 | 0.00086 | 0.340 | 0.328 | 1.05 | 0.00171 | 1.361 | 1.640 |

Results showed no pollution as 100% of samples are in the class of practically uncontaminated in the current conditions based on the Igeo index value shown in Table (5).

**Table 5: Classes of Pollution risk assessment**

| Township | Index Value | % of Sample | Classes |
|---|---|---|---|
| Kyaunggon | $I_{geo}$ | 100 | Practically uncontaminated |
| | CF | 100 | Low contamination |
| | Er | 100 | Low potential ecological risk |
| Tatkon | $I_{geo}$ | 100 | Practically uncontaminated |
| | CF | 100 | Low contamination |
| | Er | 100 | Low potential ecological risk |

According to the calculated CF values of Cd, Cr, Ni and Pb for the soil samples, the soils of both study sites were low contaminated with detected heavy metals of Cd, Cr, Ni and Pb. This rank confirmed the Er based indices pollution contamination assessment, which implied Hakanson (1980), that these study sites were on the whole, considerably a low potential ecological risk. Relationship between heavy metals.There was a positive relationship between the concentration of Pb and Cr ($R2 = 0.5002$, $P < 0.0001$) in Kyaunggon Township shown in Table (6-a).

Table 6-a: Correlation relationship between heavy metal concentrations for soil samples in Kyaunggon Township

| Unit (mg/kg) | Lead (Pb) | Cadmium (Cd) | Chromium (Cr) | Nickel (Ni) |
|---|---|---|---|---|
| Lead (Pb) | 1 | | | |
| Cadmium (Cd) | 0.137 | 1 | | |
| Chromium (Cr) | 0.4366 | -0.2289 | 1 | |
| Nickel (Ni) | 0.5002 | 0.2588 | 0.2082 | 1 |

A high response of Pb concentration was seen when Ni content was higher ($R2 = 0.5002$, $P<0.0001$) in Kyaunggon Township. The results of correlation between heavy metal concentrations indicated that the higher the concentration of Cr in the soil, the higher the concentration of Pb was found in Tatkon Township shown in Table (6-b).

**Table 6-b: Correlation relationship between heavy metal concentrations for soil samples in Tatkon Township**

| Unit (mg/kg) | Lead (Pb) | Cadmium (Cd) | Chromium (Cr) | Nickel (Ni) |
|---|---|---|---|---|
| Lead (Pb) | 1 | | | |
| Cadmium (Cd) | 0.4397 | 1 | | |
| Chromium (Cr) | 0.004 | -0.0722 | 1 | |
| Nickel (Ni) | 0.1728 | 0.2086 | -0.1002 | 1 |

In this study, Pb in the soil was positively correlated with Cr, Ni and Cd and their distributions were controlled in part by the same factor. Tume et al. (2011) found a good correlation between some trace metals (Cd, Ni, Zn, Pb, Cu and Cr). It also reflects their natural anthropogenic characteristics that might be associated mostly with a single source. Zhang et al. (2019) also reported that the relationship between heavy metal concentration indicting similar geochemical behavior or input sources is likely related to the use of pesticides and fertilizers.

**Heavy metal concentration of water samples**

The evaluation of heavy metals concentration in water samples was carried out in the study area of Kyaunggon Township and Tatkon Township. Four different metals such as Cd, Cr, Ni and Pb were assessed from the pumped irrigated water of some creeks, river and tube well. The most abundant heavy metal was Pb with an average concentration of 0.0613 mg/kg in Kyaunggon Township as shown in Table (7).

**Table 7: Heavy metal concentration (mg/kg) in the irrigation water of Kyaunggon Township**

| Sample No. | Water Source | Cd | Cr | Ni | Pb |
|---|---|---|---|---|---|
| W1 | Tube well | 0.023 | ND | ND | ND |
| W2 | Tube well | 0.01 | ND | ND | 0.1 |
| W3 | Tube well | ND | ND | ND | 0.12 |
| W4 | Tube well | 0.015 | 0.03 | ND | ND |
| W5 | Tube well | ND | ND | ND | 0.12 |
| W6 | Tube well | 0.011 | ND | ND | ND |
| W7 | Tube well | 0.012 | 0.03 | ND | ND |
| W8 | Tube well | 0.014 | ND | ND | 0.06 |
| W9 | Tube well | 0.015 | 0.03 | ND | ND |
| W10 | Tube well | 0.016 | 0.02 | ND | ND |
| W11 | Tube well | ND | ND | ND | 0.09 |

| Sample No. | Water Source | Cd | Cr | Ni | Pb |
|---|---|---|---|---|---|
| W12 | Tube well | ND | ND | ND | 0.12 |
| W13 | Tube well | 0.011 | ND | ND | ND |
| W14 | Tube well | 0.025 | ND | ND | ND |
| W15 | Tube well | 0.01 | ND | ND | 0.12 |
| W16 | River | 0.008 | ND | ND | 0.06 |
| W17 | Tube well | 0.01 | ND | ND | 0.03 |
| W18 | Tube well | 0.019 | ND | ND | 0.07 |
| W19 | Tube well | 0.012 | ND | ND | 0.07 |
| W20 | Tube well | 0.014 | ND | ND | 0.16 |
| W21 | Tube well | 0.012 | ND | ND | 0.07 |
| W22 | Tube well | 0.015 | ND | ND | 0.14 |
| W23 | River | 0.013 | ND | ND | 0.08 |
| Mean | | 0.012 | 0.005 | - | 0.061 |
| Minimum | | 0 | 0 | - | 0 |
| Maximum | | 0.025 | 0.03 | - | 0.16 |
| Standard Deviation | | 0.007 | 0.01 | - | 0.0454 |
| Maximum Permissible Limit | | 0.01 | 0.55 | 0.2 | 0.1 |

*ND=Not detected

The trend of detected heavy metal concentration in irrigation water was found in order Pb (0.03-0.16 mg/kg) > Cr (0.021-0.03mg/kg) > Cd (0.008-0.025 mg/kg). The Ni was not found in any samples of this study area. Cr values of water samples varied from 0.021 to 0.03 mg/kg with the mean value of 0.005 mg/kg. No Cr detection in about 82% of the samples was found and the reaming samples from Sa Bai Yon, Let Pan Chaung, Seik Hpu Ni, and Yaung Pyit Kwin village tracts, which were located the western part of the study area had low concentration (0.021 -0.030 mg/kg) of Cr. Thus, the concentration of Cr showed normal values within the recommended MPL (0.55 mg/kg) by the FAO. The concentrations of Cd, Cr, Ni and Pb in water samples for Kyaunggon Township survey area were shown in Figure (8-a) to (8-d).

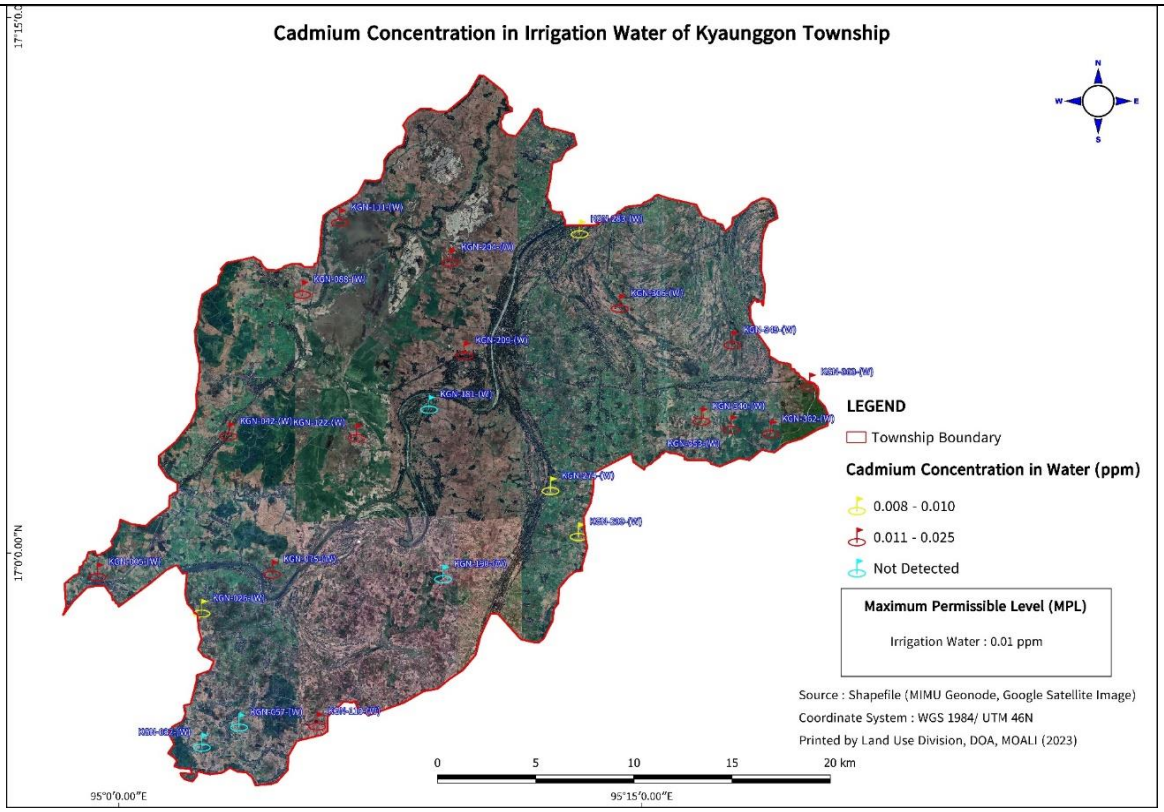


Figure (8-a). Cadmium (Cd) concentration in irrigation water of Kyaunggon Township

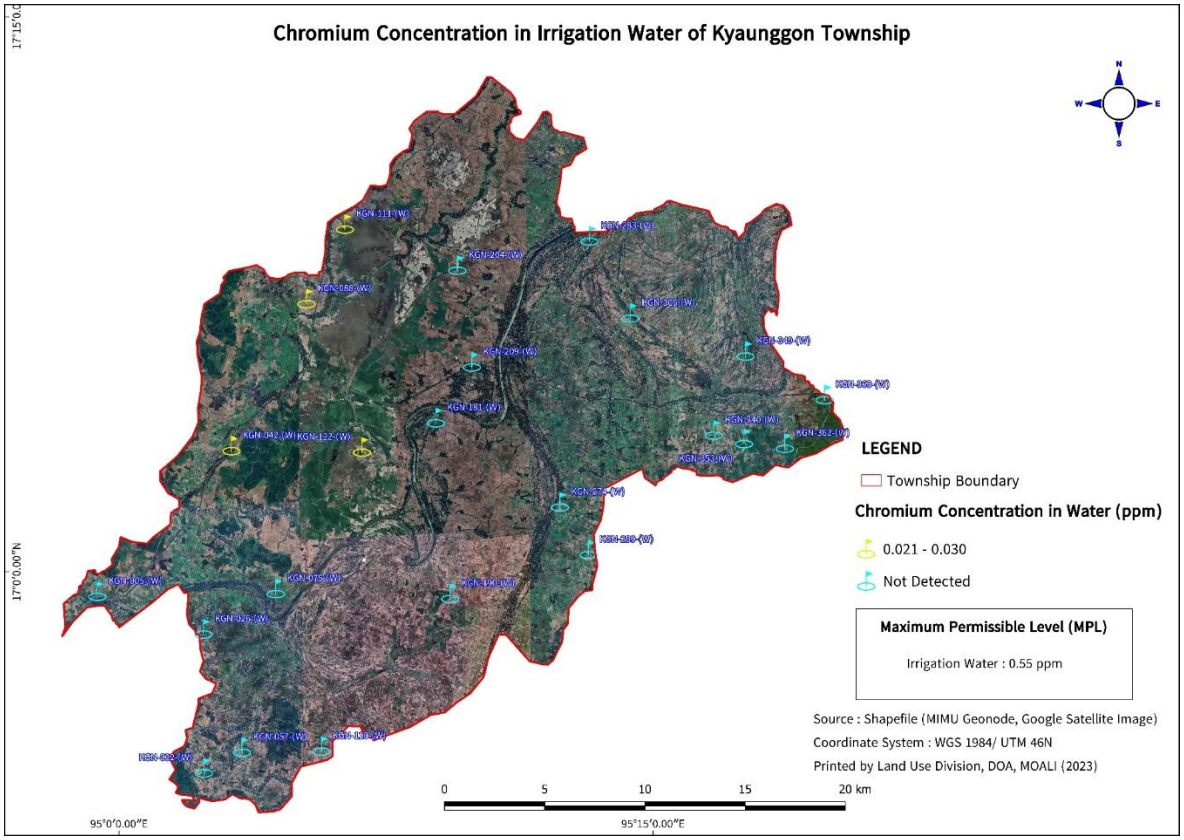


Figure (8-b). Chromium (Cr) concentration in irrigation water of Kyaunggon Township

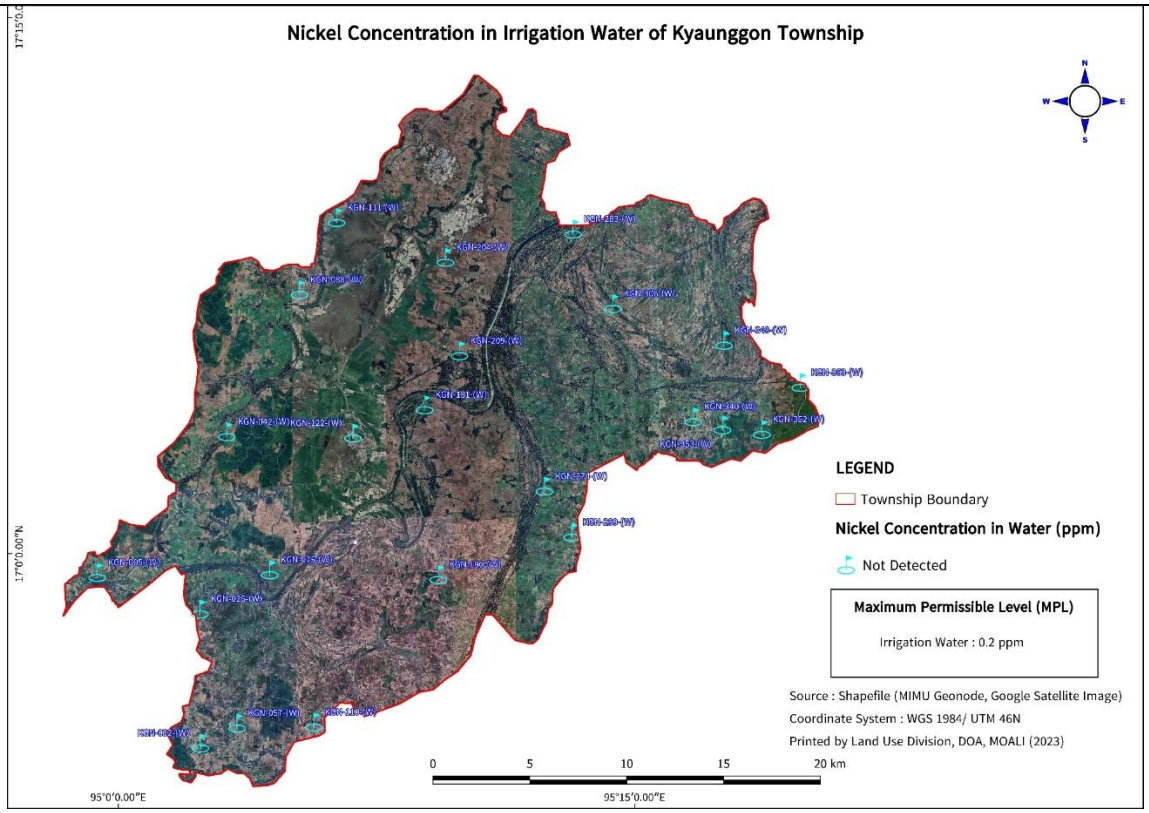


Figure (8-c). Nickel (Ni) concentration in irrigation water of Kyaunggon Township

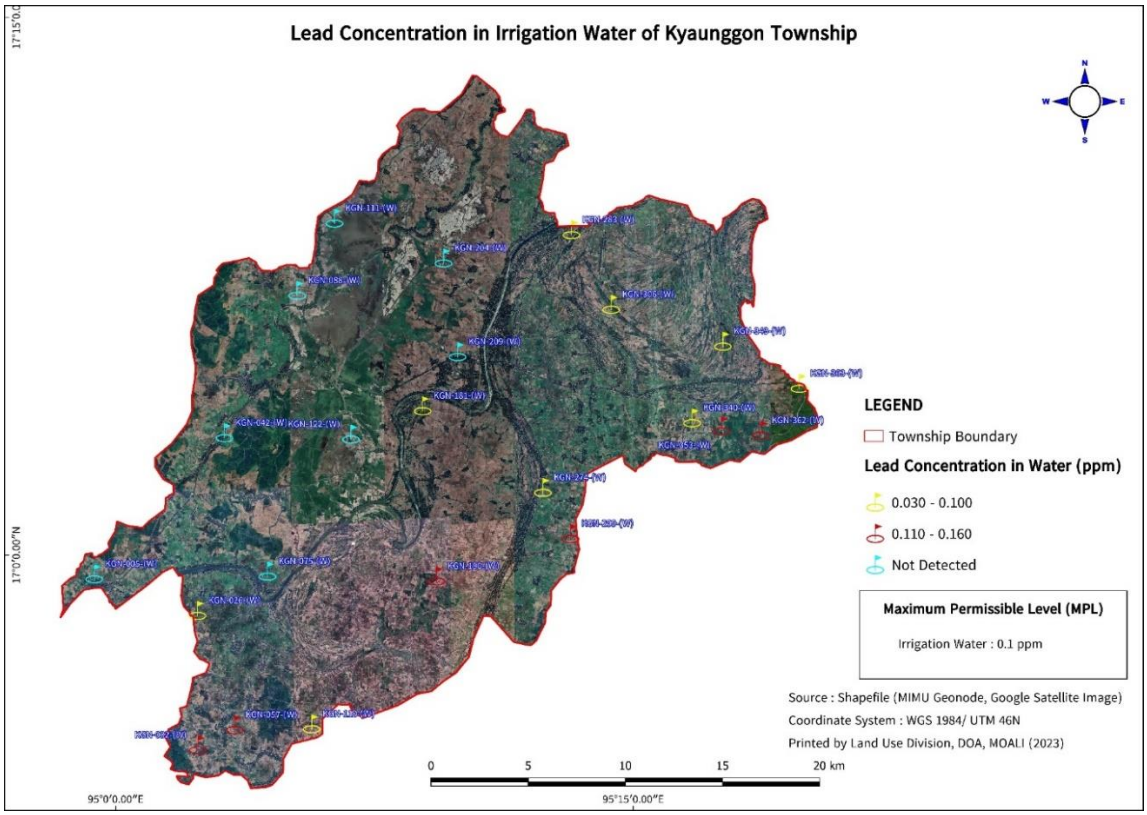


Figure (8-d). Lead (Pb) concentration in irrigation water of Kyaunggon Township

However, 26.08 % of samples from tube well of the Ka Nyin Thone Sint, Yone Pin, Hpone Soe, Seik Thar, Ah Shey Chaung, and Pauk Ngu village tracts, which were located in the eastern and southern parts of Kyaunggon township showed higher concentration of Pb than MPL (0.1 mg/kg) by FAO (U. Ewers, 1991). Results also showed that 78. 26% of samples of tube well were slightly above the MPL value of Cd. The highest concentration of Cd in water sample were found in some villages including the Kun Chan Kone and Byeik Gyi village tracts. The lowest Cd concentration were found in Kyar kaik, Seik Thar, Ah Shey Chaung, Ba Li Daunt and Pauk Ngu village tracts, which were located in the different parts of this area.

There are a few available comprehensive researches concerning the quality of water used in irrigation of agricultural crops considering Pb and Cd contamination in the study area and other region of Myanmar. This makes it difficult to compare the results of present study with other research findings. The contamination of Pb and Cd was found in some samples of tube well which were the major source of irrigation in the study area, indicating a natural contribution to the groundwater quality. Groundwater in Myanmar is of vital importance, particularly because of providing up to 80% of irrigation supplies in some areas (Viossanges et al., 2017). The widespread understanding of groundwater chemical quality is much more limited as compared to other countries in the South/ Southeast Asia region (Tun, 2003; Smedley, 2005; Mukherjee et al., 2006; van Geen et al., 2014; Bacquart et al., 2015).

According to Krishna and Mohan (2014), Pb and Cd found in water may come from both natural (weathering of bedrock) and anthropogenic (mining, industry and agriculture) sources. In our study area, this contamination could be of geogenic origin, a result of natural conditions in the aquifers. However, no data for occurrence of geogenic contaminants in the study area are available. Since natural or geogenic background concentrations of heavy metals vary significantly from one area to another (Bradl, 2005), contamination of Pb and Cd was found in some tube well of the study area.

Nevertheless, the natural processes alone may not be a sufficient explanation of the observed Pb and Cd concentrations. Pb and Cd are mainly introduced into the groundwater by agricultural and industrial activities, landfilling, mining and transportation. The transport of these metals in the groundwater might follow several distinct paths (Adriano, 2001). All tube well analyzed here were located in the area used for intensive agriculture with practices of yearly application of pesticides and herbicides, which could be also a source of heavy metal contamination in this area. In addition, some factors such as application of fertilizers, manures, in crop production and several number of rice milling plants could be attributed to the observed high level of Pb and Cd

concentration in this study area. The heavy metal concentrations in the water samples analyzed in Tatkon Township is shown in Table (8).

**Table 8: Heavy metal concentration (mg/kg) in the irrigation water in Tatkon Township**

| Sample no. | Water Source | Cd | Cr | Ni | Pb |
|---|---|---|---|---|---|
| W1 | Canal | 0.001 | ND | ND | 0.01 |
| W2 | Tube well | 0.002 | ND | ND | 0.02 |
| W3 | Canal | 0.001 | ND | ND | 0.03 |
| W4 | Tube well | 0.002 | ND | ND | 0.02 |
| W5 | Canal | 0.001 | ND | ND | 0.04 |
| W6 | Tube well | 0.003 | ND | ND | 0.06 |
| W7 | Tube well | 0.005 | ND | ND | 0.09 |
| W8 | Tube well | 0.005 | ND | ND | ND |
| W9 | Tube well | 0.004 | ND | ND | ND |
| W10 | Tube well | 0.007 | ND | ND | ND |
| W11 | Tube well | 0.007 | ND | ND | 0.01 |
| W12 | Tube well | 0.007 | ND | ND | 0.03 |
| W13 | Canal | 0.005 | ND | ND | 0.07 |
| W14 | Tube well | 0.006 | ND | ND | 0.05 |
| W15 | Tube well | 0.008 | ND | ND | 0.08 |
| W16 | Tube well | 0.009 | ND | ND | 0.07 |
| Mean | | 0.005 | - | - | 0.036 |
| Minimum | | 0.001 | - | - | 0.00 |
| Maximum | | 0.009 | - | - | 0.09 |
| Standard Deviation | | 0.003 | - | - | 0.03 |
| Maximum Permissible Limit | | 0.01 | 0.55 | 0.2 | 0.1 |

*ND = not detected

Among the detected heavy metals, Cr and Ni were not detected in the water samples in this study area. The average results obtained for Cd for all sample analyzed varied between 0.001 to 0.009 mg/kg with the average value of 0.005 mg/kg. Three sampling points of tube well water from Kin Mun Tan village out of 16 sample points showed not detected Pb values and the remaining

sampling points showed the Pb concentration with the values ranged from 0.01 to 0.09 mg/kg. None of the average Pb and Cd concentrations in the water samples from this study area analyzed were higher than the FAO standard of 0.1 mg/kg and 0.01 mg/kg, respectively. The sequence of detected metal concentrations in the water samples was Pb > Cd for Tatkon Township with concentrations (mg/kg) of 0.036 > 0.005, respectively. The concentrations of Cd, Cr, Ni and Pb in water samples for Tatkon Township survey area were shown in Figure (9-a) to (9-d).

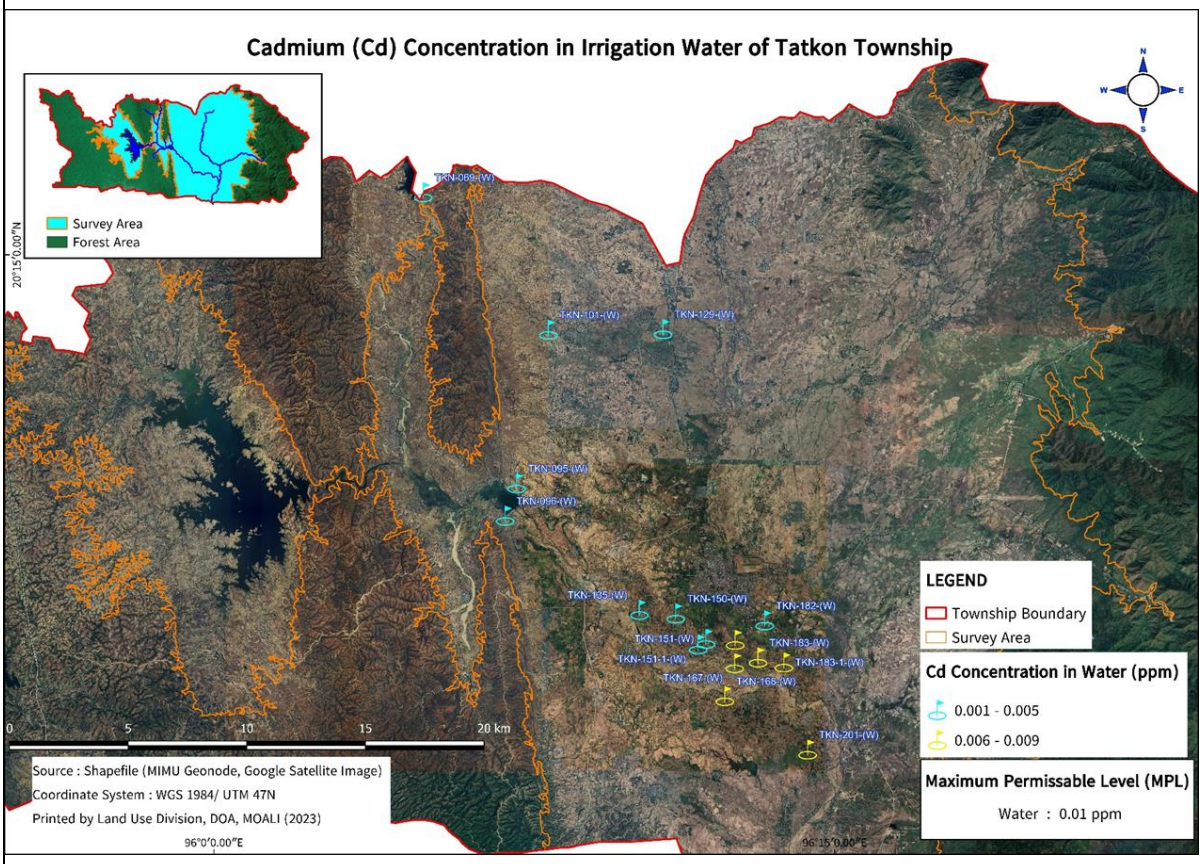


Figure (9-a). Cadmium (Cd) concentration in irrigation water of Tatkon Township

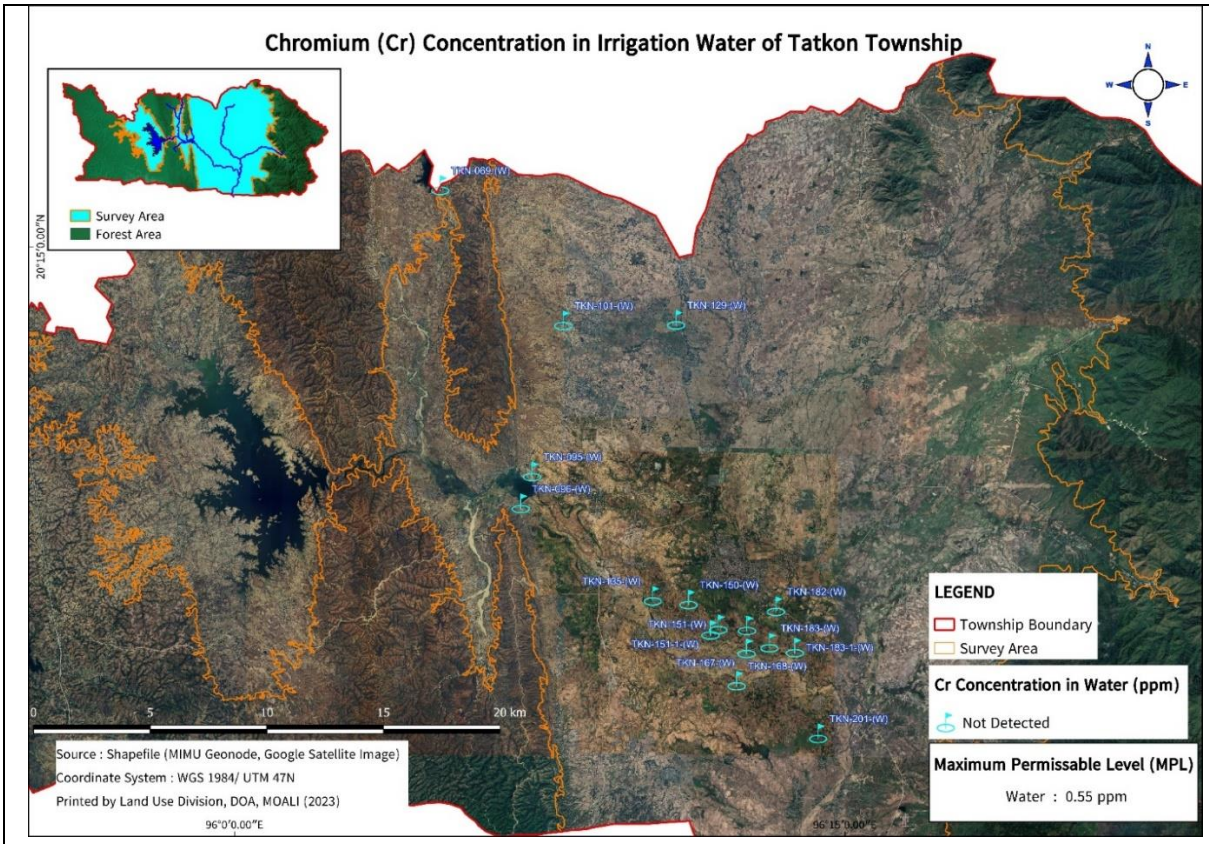


Figure (9-b). Chromium (Cr) concentration in irrigation water of Tatkon Township

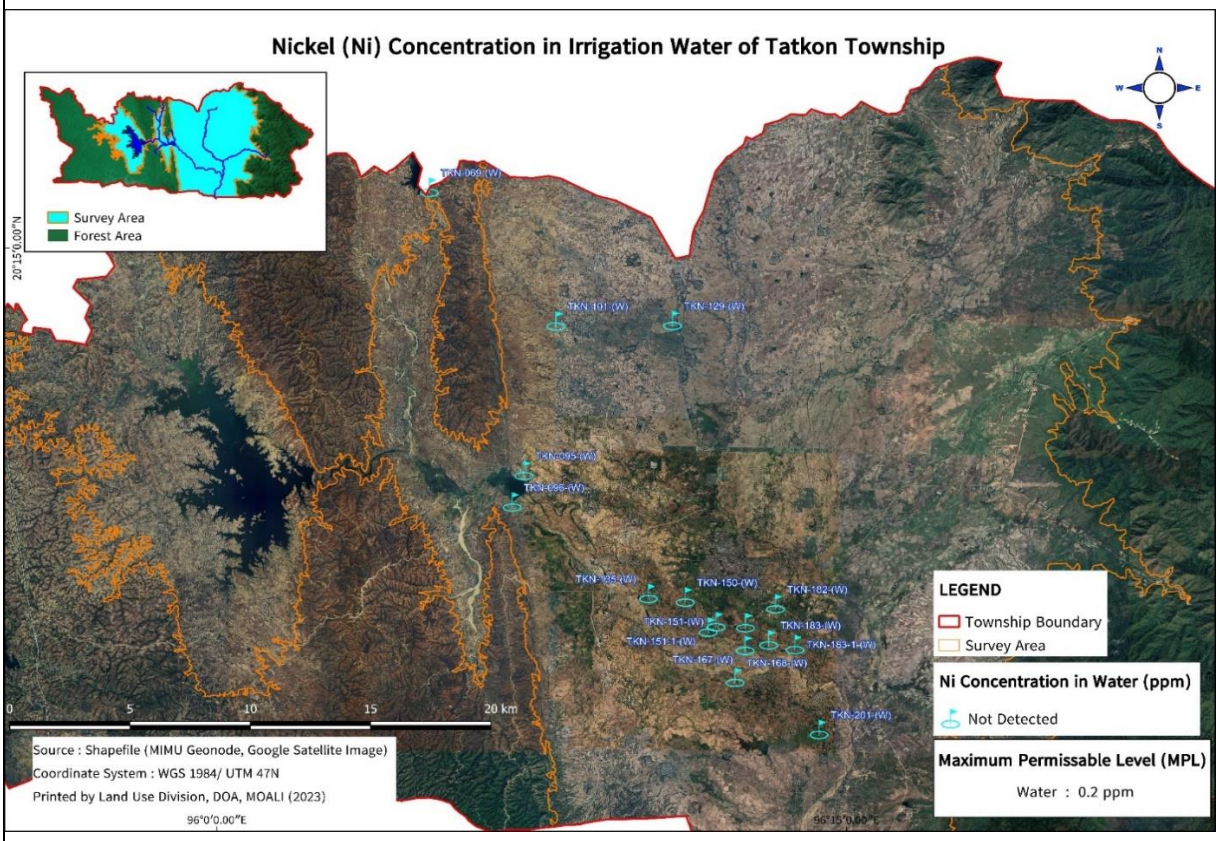


Figure (9-c). Nickel (Ni) concentration in irrigation water of Tatkon Township

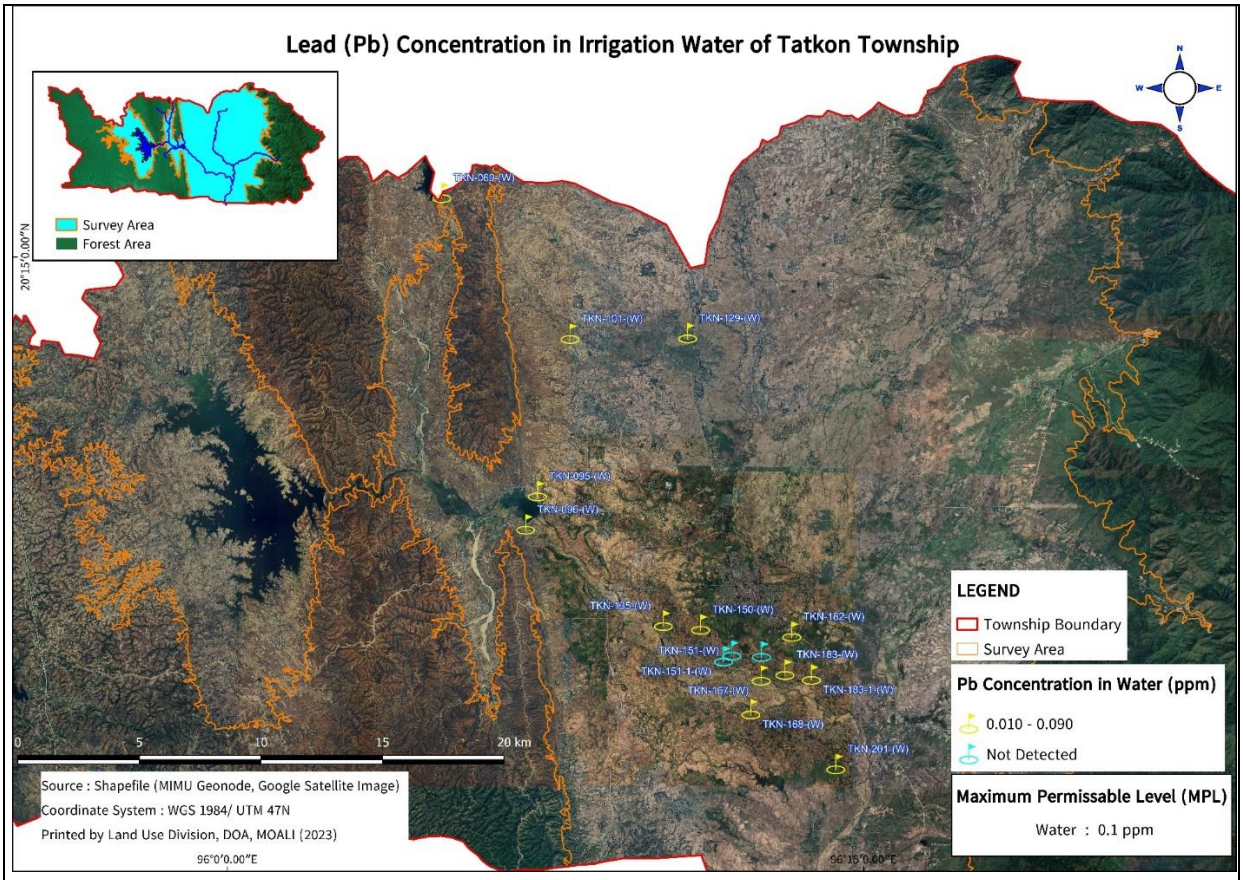


Figure (9-d). Lead (Pb) concentration in irrigation water of Tatkon Township

## A.4 Training for farmers and DoA staffs

Under the activity of training for farmers and Department of Agriculture's extension staff, the two days trainings entitled of "nutrient management, heavy metal pollution and soil and water sampling techniques" were conducted at the target region of Ayeyarwady and Nay Pyi Taw. In Ayawaddy region, two times of trainings at Kyaungon and Yekyi Township. In Nay Pyi Taw region, two times of trainings were held at Lewe and Tatkon township.

**Training Plans**

| Sr. | Townships | Number of trainings | At the place of the region | Date From - to |
|---|---|---|---|---|
| 1. | Ayeyarwady Region | | | |
| | Kyaungon township | 1 time | Knowledge center | 5.3.2023 to 6.3.2023 |
| | Yekyi township | 1 time | At DoA office | 9.5.2023 to 10.5.2023 |
| 2. | Nay Pyi Taw Region | | | |
| | Lewe township | 1 time | Monastery | 5.6.2023 to 6.6.2023 |
| | Tatkon township | 1 time | Knowledge center | 8.6.2023 to 9.6.2023 |

The training aims to increase awareness on heavy metal contamination in cultivated soil and its risk for safety crop production. The training approached to catch the basic needs of soil management for crop productions and risk of heavy metal contamination and its remediation. It includes general knowledge on importance of soil health. The detail topics were Soil fertility, Plant Nutrient and kinds of heavy metal and its hazard, Soil health and Heavy metal contamination and remediation methods, Green mauring and composting methods, application of compost and green manure and theory and practical application of Digital Survey Collection Methods (Kobo Toolbox), hazard of agrochemical inputs and good agricultural practices (GAP). The training methodology was interactive as the trainers ensured that knowledge was not only disseminated but accurately perceived and understood by the participants. In order to ensure this, the trainers engaged with the participants in discussions and kept the trainings open for feedback, queries suggestions and group presentation. These mutual interaction and discussions were supported through training material such as pre and post-test, power point presentations and handouts.

**Training objectives**

The objective of two days trainings is to increase awareness on Heavy metal contamination and capacity building of farmers and staffs at Department of Agriculture.

**Participants' profile**

The training participants included Department of Agriculture's extension staff and farmers. Staffs from DoA are mainly responsible for extension education to farmers. Those persons are key for dissemination knowledge and information to farmers. Therefore, improving Capacity building of those are important. Farmers who were selected as trainees are mostly cultivating rice, vegetable and pulses. Generally, cash crop cultivating farmers have relatively higher income and they usually use the relatively high amount of agrochemicals. Most of the farmers in both regions are using tube well during dry season for irrigation purpose. The farmers have been selected based on their crop productions, interest and riskiness of the region. The trainings considered the gender issue. Most of the farmer household head are male. It can be seen that the numbers of male farmer trainees are much more than female trainees. However, as for DoA staffs, female staff trainees are more than male staffs. The numbers of participant with respect to the region are mentioned in the table below.

| Sr. | Townships | Number of trainees from DoA | Male and female ratio | Number of trainees farmers | Male and female ratio | Total number of trainees |
|---|---|---|---|---|---|---|
| 1. | Ayeyarwady Region | | | | | |
| | Kyaunggon township | 15 | 8:7 | 40 | 38:2 | 55 |
| | Yekyi township | 25 | 24:1 | 25 | 8:17 | 50 |
| 2. | Nay Pyi Taw Region | | | | | |
| | Lewe township | 15 | 6:9 | 35 | 25:10 | 50 |
| | Tatkone township | 10 | 3:7 | 35 | 26:9 | 45 |

**Resource persons' profile**

Training Team is comprised of the specialist from the specific area of knowledge as mentioned in the table. The sessions conducted by them is shown in Annex III. All the resource person are expertise for their specific tittle for the training. They have well experience at their field and provided perfect discussion with farmers.

| No. | Name | Designation | Degree | Division/Dept. |
|---|---|---|---|---|
| 1. | Mrs. Naing Naing Moe | Assistant Director, GIS Specialist | M.Sc | Land Use Division |
| 2. | Dr. Khin Khin Mu | Staff Officer, Nutrient Management Specialist | Ph.D | Land Use Division |
| 3. | Dr. Cho Mar Htwe | Staff Officer, Laboratory Specialist | Ph.D | Land Use Division, Mandalay |
| 4. | Dr. Sein Sein Mu | Staff Officer, Socioeconomic Specialist | Ph.D | Land Use Division, Pyin Oo Lwin |
| 5. | Dr. Khin Nyunt Yi | Assistant Director, Entomologist | Ph.D | Plant Protection |
| 6. | Dr. Wunna Tun | Staff Officer, GAP specialist | Ph.D | Horticulture, Vegetable and Biotechnology |
| 7. | Ms. Myint Myint Tun | Dy. Staff Officer Soil management specialist, Environmental Soil Science | MSc | Land Use Division |

**Training Program**

All the trainings have arranged for two days and organized according to the schedule (See in Annex III). Each training has managed as follow;

**Day 01:**

**Session I.** The training was formally initiated by the relevant township officer of Department of Agriculture and they warmly welcomed the participants, thanked giving the time to attend the trainings. And then Mrs. May Phyoe Way, project coordinator shared about the project and explain the scope of the project to catch up the objectives of trainings effectively. The training is tight and organized to be time efficient meanwhile persuading the interest of the participants.

**Session II.** Soil fertility, Plant nutrient and Heavy Metal was explained by Dr. Cho Mar Htwe with the help of PowerPoint presentation. She explained detail on soil properties, soil health for agriculture, importance of soil fertility, heavy metals in soil and water and how heavy metals contamination and remediation for the sustainable agricultural systems. The participants asked questions and discussions on the role of heavy metals and locally adapted remediation measures.

**Session III.** This session introduced the integrated nutrient management (INM) by Dr, Khin Khin Mu with the PowerPoint presentation. She detail explained the components of INM including the organic manures, green manures, using bio fertilizers, cop rotation, crop intercropping, crop residues and organic wastes. Moreover, better plant management, impact of crop production inputs such as fertilizers, pesticides on soil health.

**Session IV.** In this session, the participants were mainly introduced the sampling techniques of soil and water for assessment of heavy metal contamination by Mrs. Naing Naing Moe. Moreover, the participants gained knowledge on the advantages of soil sampling in their field.

**Session V.** Ms. Myint Myint Tun introduced the digital survey collection methods by using KoBo Toolbox theoretically and practically to only staff. The staff practiced and made the survey questions by using KoBo.

**Day 02:**

**Session I.** The participants registered and warmly welcomed by the trainings.

**Session II.** This session began with systematic application of Herbicides, Pesticide and damages by Dr. Khin Nyunt Yi. She explained the handling and application of pesticides and herbicides in which heavy metals are existed, using the personal protective equipment while the farmers applied, types of nozzles for specific agrochemicals for sprayers, about the minimum pre-harvest intervals to reduce the residues on crop products. The participants gained knowledge about the systematic usage of agrochemicals for crop production.

**Session III.** In this session, Dr. Cho Mar Htwe shared about the green manure and application method with mutual discussion with the participants.

**Session IV.** Dr. Sein Sein Mu discussed the compost making procedures using farm waste with theory and practically. The participants are grouped and made the compost practically. They satisfied this session and all group actively participated compost making procedures.

**Session V.** This session was focused on the good agricultural practices (GAP) for safety crop production by Dr. Wunna Tun with the PowerPoint presentation. The participants gained the knowledge on the GAP certification process and they wanted to get the certificate for their crop by using the GAP.

**Training Evaluation**

At the end of the trainings, evaluation test has conducted to farmers and extension staff to assess their knowledge and awareness on heavy metal contamination, risk of heavy metal, soil and plant nutrient management, agro chemical handling practices and (soil and water sample collection techniques applying KoBo Tool – this training is only for extension staff). Assessing the effect of training activities is important for the proper management of training to achieve the training objectives and to survey whether the respective training properly addressed the needs and satisfaction of target group.

The evaluation of training helps to identify new training needs and the feedback of participants was particularly important for project implementation and continuous updating of the training needs. On the topics of "Evaluation of programme content, Evaluation of trainers in the programe, Evaluation of training courses of risk of heavy metal, ways and remedies to reduce the risk of heavy metal-application of organic manure, green manure and GAP and Evaluation of KoBo Tool application", participants were asked to evaluate from a scale of "very negative" to "very positive" in In cases wherein participants didn't answer to the item in question or provided an invalid answer we used "non applicable".

An overall analysis of the answers to the training evaluation questionnaire in both Ayeyarwady and Nay Pyi Taw region allows us to conclude that participants were satisfied with the training programme and trainers with very little to no negative answers. Relative to the courses of the training, nearly all of the participants were greatly pleased with the opportunity to attend training on the subject, which was valued as very useful for their crop production and knowledge on heavy metal contamination. In general, the training programme succeeded in the satisfaction of the training needs of the participants and in the achievement of the learning objectives, increasing their awareness and knowledge, reflection and dissemination on the content, application and relevance of the project implementation. Regarding the "KOBO Tool application course" of training, 90 % of the respondents considered it positive and 85 % very positive, which expresses the satisfaction of the participants with the training provided to apply in the practical field.

**Future work plan**

There are a total of four primary activities in the first phase. Three of these activities have been successfully completed according to the initial plan, with the exception of soil sampling, analysis, and mapping, which are currently at a 50% completion stage, and the remaining tasks are in progress. Expert meetings have taken place in Nay Pyi Taw City, while the other activities have been carried out in the designated regions of Ayawaddy and Nay Pyi Taw. In each of these regions, a socioeconomic survey has been conducted, and soil sampling, analysis, and mapping have been performed in both regions, along with two times of training sessions.

| Sr. | Component | Activities | Proposed | Finished | Remark |
|---|---|---|---|---|---|
| 1. | A.1 | Expert Meeting | 3 times | 3 times | 100% |
| 2. | A.2 | Socioeconomic survey | 2 regions | 2 regions | 100% |
| 3. | A.3 | Soil sampling/analyzing and mapping | 4 regions | 2 regions | 50% |
| 4. | A.4 | Trainings | 4 times | 4 times | 100% |

In the second phase, there are a total of four primary activities, which will be implemented upon receiving the second budget disbursement. These activities include a single expert meeting, four training sessions in the designated regions of Shan State and Mandalay, and one socioeconomic survey in each of these regions. Additionally, the remaining 50% of soil sampling, analysis, and mapping will be carried out in the regions of Shan State and Mandalay.

| Sr. | Component | Activities | Proposed | Finished | Remark |
|---|---|---|---|---|---|
| 1. | B.1 | Expert Meeting | 1 time | Not yet | |
| 2. | B.2 | Socioeconomic survey | 2 regions | Not yet | |
| 3. | B.3 | Trainings | 4 times | Not yet | |
| 4. | B.4 | Presentation on abroad | One time | Not yet | |
| 5. | A.3 | Soil sampling/analyzing and mapping | 2 times (50%) | Not yet | |

At the end of this month, baseline survey and collecting of samples will be done in the third project area (Kalaw township, Shan State). Fourth survey project area (Kyaukse township, Mandalay Region) will be implemented at mid of coming December. Immediate after collecting the samples and analyzed the spatial distribution maps of these two townships will be produced. Parallelly trainings will be held in this survey area.

## Problems Encountered during implementation

During the analysis of arsenic (As) AAS Graphite in Land Use Division shows has a structural problem. To overcome this problem a new AAS hydride generation will be purchased with LUD, DoA Government budget and As will be analyzed at coming end of January 2024. As for conducting trainings, it has been paid much attention to gender issue. Sometime it is difficult to have target farmers especially in cropping season. Likewise, it is essential to schedule soil and water sampling activities in a manner that avoids interfering with the cropping season. Regarding budgeting, it is imperative that some proposed expenses are needed to be adjusted to align with Myanmar's financial regulations.

## Financial Explanation

Upon the received of budget for first disbursement 112005 USD, it has been used for designated activities in line with budget proposal. Detail calculation of each activity has been reported separately. Total expenditure for first phase is 112006 USD as mentioned in the table (1). For the second phase, approved budget is mentioned in the table (2) with respect to the activities.

**Table (1) Budget explanation for first disbursement**

| Sr. | Component | Activities | Approved Budget (USD) | Actual Expenditure (USD) | Balance (USD) |
|---|---|---|---|---|---|
| 1. | A.1 | Expert Meeting | 11170 | 10389 | 781 |

| | | | | | |
|---|---|---|---|---|---|
| 2. | A.2 | Socioeconomic survey | 4387 | 4100 | 287 |
| 3. | A.3 | Soil sampling/analyzing and mapping | 138822 | 69862 | 68960 |
| 4. | A.4 | Trainings | 31565 | 27655 | 3900 |
| | | | | 112006 | |

**Table (2) Budget explanation for second and third disbursement**

| Sr. | Component | Activities | Approved Budget (USD) | Actual Expenditure (USD) | Remark |
|---|---|---|---|---|---|
| 1. | B.1 | Expert Meeting | 4098 | - | |
| 2. | B.2 | Socioeconomic survey | 4538 | - | |
| 3. | B.3 | Trainings | 24289 | - | |
| 4. | B.4 | Presentation on abroad | 5136 | - | |
| 5. | A.3 | Soil sampling/analyzing and mapping | 68960 | - | Continued from first phase |

## Summary

Heavy metals are important pollutants in the environment and can have accumulate to toxic levels in agricultural soils, thereby adversely affecting crop health and productivity. This can also very seriously affect on aquatic organisms and subsequently on the consumers. Therefore, this project mainly assessed the contamination level of heavy metals and pollution risk in major agricultural growing regions. Four State and Regions were selected as project area. Socio economic team conducted with the cooperation of local extension staff.in two Regions. Detailed activities of socio-economic team are reported separately. Soil and water samples are collected in two Townships in Ayeyarwady Region and Naypyitaw Union Territories. Samples are collected and analyzed the content of heavy metals. To provide the quantitative and qualitative information for heavy metal contamination spatial distribution of each heavy metal in two Townships are produced. In order to remove the challenges of limiting capacity buildings of staff and farmers, limited information of heavy metal contamination and remediation of contaminated agricultural soils and irrigation water trainings to extension staff and farmers are done in two townships.

## Reference


Adriano, D.C (2001) Trace Elements in Terrestrial Environments: Biogeochemistry, Bioavailability and Risks of Metals. 2nd Edition, Springer, New York, 867. http://dx.doi.org/10.1007/978-0-387-21510-5

Bacquart, Thomas, et al. "Multiple inorganic toxic substances contaminating the groundwater of Myingyan Township, Myanmar: Arsenic, manganese, fluoride, iron, and uranium." Science of the Total Environment 517 (2015): 232-245.

Balli, N., and E. Leghouchi. "Assessment of lead and cadmium in groundwater sources used for drinking purposes in Jijel (Northeastern Algeria)." Glob NEST J 20.2 (2018): 417-23.

Bradl, H. (2005) Heavy Metals in the Environment: Origin, Interaction and Remediation. Elsevier/Academic Press, London.

Chen, Xiao-Xia, Yan-Ming Xu, and Andy TY Lau. "Metabolic effects of long-term cadmium exposure: An overview." Environmental Science and Pollution Research 29.60 (2022): 89874-89888.

Cho, A., Belton, B., & Boughton, D. (2017). Crop production and profitability in Ayeyarwady and Yangon (No. 1879-2017-5321).

Ewers, U. (1991). Standards, guidelines and legislative regulations concerning metals and their compounds. Metals and their compounds in the environment, 760-710.

Hakanson, L.: An Ecological Risk Index for Aquatic Pollution Control: A Sedimentological Approach, Water Res., 14, 975–1001, doi:10.1016/0043-1354(80)90143-8, 1980.

http://themimu.info/sites/themimu.info/files/assessment_file_attachments/IFPRI_Myanmar-SSP_WP10.pdf

IFPRI (2021). The outlook for Myanmar’s inorganic fertilizer use and 2021 crop harvest

Jaber, Lubna, et al. "Adsorptive removal of lead and chromate ions from water by using iron-doped granular activated carbon obtained from coconut shells." Sustainability 14.17 (2022): 10877.

Kabata-Pendias, A. and Mukherjee, A.B. (2007) Trace Elements from Soil to Human. Springer-

Verlag, Berlin, 23

Krishna, A.K. and Mohan, K.R. (2014) Risk Assessment of Heavy Metals and Their Source Distribution in Waters of a Contaminated Industrial Site. Environmental Science and Pollution Research, 21, 3653-3669. https://doi.org/10.1007/s11356-013-2359-5

Kwee, Y., & Soe, K. M. M. (2021). Soil quality of the tea and apple-growing sites in Mindat District, Chin state, Myanmar: A preliminary study. Zemljište i biljka, 70(1), 27-40.

MacTavish, Robert C., Liam W. Rémillard, and Colleen M. Davison. "Environmental lead exposure and adult literacy in Myanmar: An exploratory study of potential associations at the township level." International Journal of Environmental Research and Public Health 15.6 (2018): 1086.

Maung, Htoo Ei Pyae Phyo, et al. Farmers' Weed Management Practices in Green Gram-based Cropping Systems in Central Dry Zone of Myanmar. Diss. MERAL Portal, 2018.

Mukherjee, Amitava, et al. "Arsenic contamination in groundwater: a global perspective with emphasis on the Asian scenario." Journal of Health, Population and Nutrition (2006): 142-163.

Niño-Savala, Andrea Giovanna, et al. "Cadmium pollution from phosphate fertilizers in arable soils and crops: An overview." Front. Agric. Sci. Eng 6 (2019): 419-430.

Omar, F.S.; Numan, A.; Duraisamy, N.; Bashir, S.; Ramesh, K.; Ramesh, S. Ultrahigh capacitance of amorphous nickel phosphate for asymmetric supercapacitor applications. RSC Adv. 2016, 6, 76298–76306. [Google Scholar] [CrossRef]

Orellana, Edith, et al. "Lead in agricultural soils and cultivated pastures irrigated with river water contaminated by mining activity." Journal of Ecological Engineering 20.8 (2019): 238-244.

Pandey, Akhilesh Kumar, Arti Gautam, and Ashish Kumar Singh. "Insight to chromium homeostasis for combating chromium contamination of soil: Phytoaccumulators-based approach." Environmental Pollution (2023): 121163.

Salman, S. A., Zeid, S. A., Seleem, E. M. M., & Abdel-Hafiz, M. A. (2019). Soil characterization and heavy metal pollution assessment in Orabi farms, El Obour, Egypt. Bulletin of the National Research Centre, 43(1), 1-13.

Sann, Aye Aye, and May Thinzar Phyo. Heavy Metal Pollution of Agricultural Soils and Vegetables of Ngazun Township, Mandalay Division. Diss. MERAL Portal, 2018.

Smedley, Pauline. "Arsenic occurrence in groundwater in South and East Asia." (2005): 20-97.

Suciu, N. A., De Vivo, R., Rizzati, N., & Capri, E. (2022). Cd content in phosphate fertilizer: Which potential risk for the environment and human health?. Current Opinion in Environmental Science & Health, 30, 100392.

Suciu, Nicoleta Alina, et al. "Cd content in phosphate fertilizer: Which potential risk for the environment and human health?." Current Opinion in Environmental Science & Health 30 (2022): 100392.

Tun, Aung Zaw, Pokkate Wongsasuluk, and Wattasit Siriwong. "Heavy metals in the soils of placer small-scale gold mining sites in Myanmar." Journal of Health and Pollution 10.27 (2020): 200911.

Tun, Tet N. "Arsenic contamination of water sources in rural Myanmar." (2003).

Turekian, K.K. and Wedepohl, K.H. (1961) Distribution of the Elements in Some Major Units of the Earth's Crust. Geological Society of America Bulletin, 72, 175-192.

Umar, A. M., & Wachiko, B. (2021). Tara Yamane (1967), Taro Yamene method for sample size calculation. The survey causes of mathematic anxiety among secondary school students in Minna metropolis mathematical association of Nigeria (MAN), 46 (1), 188.

van Geen, Alexander, et al. "Confirmation of elevated arsenic levels in groundwater of Myanmar." Science of the Total Environment 478 (2014): 21-24.

Viossanges, M., R. Johnston, and L. Drury. "Ayeyarwady State of the Basin Assessment (SOBA) 2A: Groundwater Resources." International Water Management Institue (IWMI) (2017).

Yang, Dan, et al. "Geochemical and probabilistic human health risk of chromium in mangrove sediments: A case study in Fujian, China." Chemosphere 233 (2019): 503-511.

Zhang, X., Chen, B., Yin, R., Xing, S., Fu, W., Wu, H., ... & Zhang, X. (2022). Long-term nickel contamination increased soil fungal diversity and altered fungal community structure and co-occurrence patterns in agricultural soils. Journal of Hazardous Materials, 436, 129113.

## Indicative Work Plan

| | MONTH | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TASK | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| *Output 1.* | ASSESSMENT OF HEAVY METAL CONTAMINATION IN SOIL AND WATER | | | | | | | | | | | | | | | | | | | | | | | |
| | F | M | A | M | J | J | A | S | O | N | D | J | F | M | A | M | | | | | | | | |
| *Activity 1* | *- Meeting with International and Local Experts for contamination of heavy metal contamination in soil and water* | | | | | | | | | | | | | | | | | | | | | | | |
| | *- Budget: 11170.8 + 4098.1 (15268.9) USD* | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | 75 % | | | | | | | | | | | | | | | | | | | | |
| *Activity 2* | ***- SOIL SAMPLING, ANALYZING, DATA INSTALLATION INTO MAP - BUDGET:*** *138821.80 USD* | | | | | | | | | | | | | | | | | | | | | | | |
| *Activity (2.1)* | ***SOIL SAMPLING*** | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | 50 % | | | | | | | | | | | | | | | | | |
| *Activity (2.2)* | ***ANALYZING - BUDGET:*** *USD* | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | 40 % | | | | | | | | | | | | | | | | | | | |
| *Activity (2.3)* | ***DATA INSTALLATION INTO MAP - BUDGET:*** *USD* | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | 40 % | | | | | | | | | | | | | | |
| *Output 2.* | CAPACITY BUILDING / INCREASED AWARENESS | | | | | | | | | | | | | | | | | | | | | | | |
| *Activity 3* | *Socioeconomic Survey Budget : 4387.00 +4537.87 = (8924.87 ) USD* | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | 50 % | | | | | | | | | | | | | | | | | | |
| *Activity 4* | *Trainings to Staffs and Farmers Budget : 31565 +24289 = (55854) USD* | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | 50 % | | | | | | | | | | | | | | | | | | |
| *Activity 5* | *Presenting Project result on abroad Budget 5136 USD* | | | | | | | | | | | | | | | | | | | | | | | |

# Participants List of 1st Expert Meeting

| Sr. No | Name | Affiliation | e-mail |
|---|---|---|---|
| 1 | Mr. Win Oo | Project Director, Land Use Division | winoodoa@gmail.com |
| 2 | Ms. Thuzar Myint | Former Director, Land Use Division | zarmyint@gmail.com |
| 3 | Mr. Nyunt Shwe | Professor (Retired), Yezin Agricultural University (YAU) | |
| 4 | Dr. Su Su Win | Deputy Director General (retired), Department of Agricultural Research | |
| 5 | Dr. Maw Maw Than | Director, Department of Agricultural Research | mawthan23@gmail.com |
| 6 | Dr. Ni Ni Tint | Deputy Director, Department of Agricultural Research | ninitint@gmail.com |
| 7 | Dr. San Win | Director, Environmental Conservation Department | sanwinn.edu@gmail.com |
| 8 | Ms. San San Lwin | Deputy Director, Land Use Division | landusenpt@gmail.com |
| 9 | Ms. Yin Kyi | Deputy Director, Land Use Division | landusenpt@gmail.com |
| 10 | Dr. Amy Soe | Director, International Cooperation Division (ASEAN) of Department of Planning (DoP) | dapasean@gmail.com |
| 11 | Dr. Kyaw Ngwe | Professor, YAU | dr.kyawngwe@yau.edu.mm |
| 12 | Dr. Swe Swe Mar | Professor, YAU | dr.sweswemar@yau.edu.mm |
| 13 | Dr.Thandar Nyi | Deputy Director, Land Use Division | nyi.thandar@gmail.com |

| | | | |
|---|---|---|---|
| 14 | Mrs.Naing Naing Moe | Assistant Director,<br>Land Use Division | nnmoe148@gmail.com |
| 15 | Mrs. Aye Myat Mu | Staff Officer,<br>Land Use Division | ayemyatmu906@gmail.com |
| 16 | Dr.Cho Mar Htwe | Staff Officer,<br>Land Use Division<br>(Mandalay Laboratory) | cmhtwe@gmail.com |
| 17 | Mrs. May Phyoe Way | Staff Officer<br>Land Use Division | mayphyoeway@gmail.com |
| 18 | Dr. Sein Sein Mu | Staff Officer<br>Land Use Division<br>(Pyin Oo Lwin) | seinnmu@gmail.com |
| 19 | Dr. Khin Khin Mu | Staff Officer<br>Land Use Division | khinmumu96@gmail.com |
| 20 | Dr. Thuzar Win | Staff Officer<br>Land Use Division | thuzarwin.pb@gmail.com |
| 21 | Mr.Kyaw Thet Oo | Staff Officer<br>Land Use Division | kokyawthetoo1357@gmail.com |
| 22 | Ms.Myint Myint Tun | Deputy Staff Officer,<br>Land Use Division | myintmyinttunyau@gmail.com |
| 23 | Mr. Paing Oo Zaw | Deputy Staff Officer,<br>Land Use Division | paingoozaw.yau@gmail.com |
| 24 | Mrs. Kyi Mon Thein | Deputy Staff Officer,<br>Land Use Division | kyimonthien26@gmail.com |
| 25 | Ms.Zan Zan Win | Deputy Staff Officer,<br>Land Use Division | zanzanwin.yau@gmail.com |

# Participants List of 2nd Expert Meeting

| Sr No. | Name | Affiliation | e-mail |
|---|---|---|---|
| 1 | Mr. Win Oo | Project Director, Land Use Division | winoodoa@gmail.com |
| 2 | Ms. Thuzar Myint | Former Director, Land Use Division | zarmyint@gmail.com |
| 3 | Dr.Thandar Nyi | Deputy Director, Land Use Division | nyi.thandar@gmail.com |
| 4 | Mrs.Naing Naing Moe | Assistant Director, Land Use Division | nnmoe148@gmail.com |
| 5 | Dr.Cho Mar Htwe | Staff Officer, Land Use Division(Mandalay Laboratory) | cmhtwe@gmail.com |
| 6 | Mrs. May Phyoe Way | Staff Officer, Land Use Division | mayphyoeway@gmail.com |
| 7 | Dr. Sein Sein Mu | Staff Officer In charge of Land Use Division(Pyin Oo Lwin) | seinmumu@gmail.com |
| 8 | Mr. Soe Naing Win | Assistant Director, In charge of Land Use Division(Chin) | soenaingwin@gmail.com |
| 9 | Ms. Thet Thet Tun | Assistant Director In charge of Land Use Division (Mandalay) | landusemdy@gmail.com |
| 10 | Mr. Aung Zaw Moe | Assistant Director, In charge of Land Use Division(Shan) | aaungzawmoe@gmail.com |
| 11 | Mr.Htin Kyaw Oo | Assistant Director, In charge of Land Use Division (Ayeyarwady) | htinkyawookk199@gmail.com |
| 12 | Mrs.Tin Mar Aye | Assistant Director, In charge of Land Use Division (Nay Pyi Taw) | chanmaw@gmail.com |
| 13 | Ms.Nyein Nyein San | Assistant Director, In charge of Land Use Division (Bago) | landusebgo@gmail.com |

| | | | |
|---|---|---|---|
| 14 | Ms Khin Hla Myint | Assistant Director, In charge of Land Use Division Laboratory(Mandalay) | khlmyint@gmail.com |
| 15 | Dr. Khin Khin Mu | Staff Officer, Land Use Division | khinmumu96@gmail.com |
| 16 | Dr. Thuzar Win | Staff Officer, Land Use Division | thuzarwin.pb@gmail.com |
| 17 | Mr.Kyaw Thet Oo | Staff Officer Land Use Division | kokyawthetoo1357@gmail.com |
| 18 | Mr. Paing Oo Zaw | Deputy Staff Officer, Land Use Division | paingoozaw.yau@gmail.com |
| 19 | Ms. Myint Myint Tun | Deputy Staff Officer, Land Use Division | |
| 20 | Dr.Khin Khin Wai | Deputy Staff Officer, Land Use Division | k.khinwai.yau@gmail.com |
| 21 | Mr.Moe Kyaw Thu | Deputy Staff Officer, Land Use Division | landusenpt@gmail.com |
| 22 | Ms. Sabe Oo | Deputy Staff Officer, Land Use Division | sabeloo.agri@gmail.com |
| 23 | Ms.Swe Swe Than | Deputy Staff Officer, Land Use Division | sweswethann@gmail.com |
| 24 | Ms Su Sandy Tun | Deputy Assistant Staff Officer, Land Use Division | landusenpt@gmail.com |
| 25 | Ms.Yu Nandar Myint | Assistant Staff Officer, Land Use Division | yunandarmyint144@gmail.com |

Annex I

# Participants List of 3rd Expert Meeting

| Sr No. | Name | Affiliation | e-mail |
|---|---|---|---|
| 1 | Dr. Ye Tint Tun | Director General, Department of Agriculture | dgdoa@gmail.com |
| 2 | Mr. Kyaw Swe Lin | Director General, Department of Planning | dopasean@gmail.com |
| 3 | Dr. Tun Shwe | Deputy Director General, Department of Agriculture | dydgtechnology@gmail.com |
| 4 | Mr. Thura Soe | Deputy Director General, Department of Agriculture | dydgdoa@gmail.com |
| 5 | Mr. Zaw Tun Myint | Deputy Director General, Department of Agriculture | zawhtunmyint50@gmail.com |
| 6 | Mr. Win Oo | Project Director, Land Use Division | winoodoa@gmail.com |
| 7 | Mrs. Lin Lin Thi | Director, Project Planning, Monitoring and Evaluation Division | ir2planningdoa@gmail.com |
| 8 | Dr. San Win | Director, Environmental Conservation Department | sanwinn.ecd@gmail.com |
| 9 | Dr. Aung Kyaw Thu | Research Officer. Department of Agricultural Research | aungkyawthu.dar@gmail.com |
| 10 | Ms. Nyein Nyein San | Assistant Director, In Charge of Land Use Division(Bago) | landusebago@gmail.com |
| 11 | Ms.Khin Hla Myint | Assistant Director, In Charge of Land Use Division Laboratory (Mandalay) | khlmyint1966@gmail.com |
| 12 | Dr. Myat Myat Soe | Director, Metallurgical Research Division, Department of Technology, Promotion& Coordination | dr.myatmyatsoe99@gmail.com |
| 13 | Dr.Nay Myo Htike | Deputy Director, Metallurgical Research Division Department of Technology, Promotion& Coordination | nayhtike007@gmail.com |
| 14 | Dr. Amy Soe | Director, International Cooperation Division (ASEAN) of Department of Planning (DoP) | aseandop@gmail.com |
| 15 | Dr. Kyaw Ngwe | Professor, Yezin Agricultural University | dr.kyawngwe@yau.edu.mm |
| 16 | Dr. Swe Swe Mar | Professor, Yezin Agricultural University | dr.sweswemar@yau.edu.mm |
| 17 | Dr.Thandar Nyi | Deputy Director, Land Use Division | nyi.thandar@gmail.com |
| 18 | Mrs.Naing Naing Moe | Assistant Director, In Charge of Land Use Division | nnmoe148@gmail.com |

| | | | |
|---|---|---|---|
| 19 | Mr. Aung Zaw Moe | Assistant Director, In Charge of Land Use Division(Shan) | aaungzawmoe@gmail.com |
| 20 | Dr.Cho Mar Htwe | Staff Officer, Land Use Division (Mandalay Laboratory) | cmhtwe@gmail.com |
| 21 | Mrs. May Phyoe Way | Staff Officer Land Use Division | mayphyoeway@gmail.com |
| 22 | Dr. Sein Sein Mu | Staff Officer Land Use Division(Pyin Oo Lwin) | seinnmu@gmail.com |
| 23 | Dr. Khin Khin Mu | Staff Officer Land Use Division | khinmumu96@gmail.com |
| 24 | Dr. Thuzar Win | Staff Officer Land Use Division | thuzarwin.pb@gmail.com |
| 25 | Mr. Kyaw Thet Oo | Staff Officer Land Use Division | |
| 26 | Ms.Myint Myint Tun | Deputy Staff Officer, Land Use Division | myintmyinttunyau@gmail.com |
| 27 | Mr. Moe Kyaw Thu | Deputy Staff Officer, Land Use Division | landusenpt@gmail.com |
| 28 | Mrs. Kyi Mon Thein | Deputy Staff Officer, Land Use Division | kyimonthein26@gmail.com |
| 29 | Ms.Swe Swe Than | Deputy Staff Officer, Land Use Division | sweswethan2011@gmail.com |
| 30 | Ms.May Barani Lwin | Deputy Staff Officer, Land Use Division | maybrani222@gmail.com |

# "Training of Nutrient Management, Heavy Metal Contamination and Soil and Water Sampling Techniques" Attendant Staff List

Place-Ye Kyi Township, Ayeyarwady Region Date-9-10.5.2023

| No. | Name | Position |
|---|---|---|
| 1 | U Hla Myo Nwe | Staff Officer |
| 2 | Daw Khin Moe Oo | Deputy Staff Officer |
| 3 | Daw Yi Yi Lwin | Deputy Staff Officer |
| 4 | U Saw Htoo | Deputy Staff Officer |
| 5 | Daw Ohmar Win | Assistant Staff Officer |
| 6 | Daw Nway Oo Myint | Assistant Staff Officer |
| 7 | U Ohn San | Assistant Staff Officer |
| 8 | U Zaw Min Oo | Deputy Assistant Staff Officer |
| 9 | U Myo Htet Aung | Deputy Assistant Staff Officer |
| 10 | U Myo Min Thein | Deputy Assistant Staff Officer |
| 11 | U Hein Thant | Deputy Assistant Staff Officer |
| 12 | U Thu Ya Lwin | Deputy Assistant Staff Officer |
| 13 | Daw Zu Myat Chal | Deputy Assistant Staff Officer |
| 14 | Daw Phyo Pa Pa Nyein | Deputy Assistant Staff Officer |
| 15 | Daw Khaing Zin Kyaw | Deputy Assistant Staff Officer |
| 16 | Daw Ei Thazin Phyo | Deputy Assistant Staff Officer |
| 17 | Daw Ei Thazin Tun | Deputy Assistant Staff Officer |
| 18 | Daw Hnin Pyone Wai | Deputy Assistant Staff Officer |
| 19 | Daw Lamin Po Po | Deputy Assistant Staff Officer |
| 20 | Daw Kyi Lei Lei Soe | Deputy Assistant Staff Officer |
| 21 | Daw Aye Sandar Kyaw | Deputy Assistant Staff Officer |
| 22 | Daw Nandar Lin | Deputy Assistant Staff Officer |
| 23 | Daw Aye Ohmar Thin | Deputy Assistant Staff Officer |
| 24 | Daw Than Than Aye | Deputy Assistant Staff Officer |
| 25 | Daw Sandar Myint | Deputy Assistant Staff Officer |

**“Training of Nutrient Management, Heavy Metal Contamination and Soil and Water Sampling Techniques” Attendant Farmers List**

Place-Ye Kyi Township, Ayeyarwady Region Date-9-10.5.2023

| No. | Name | Position |
|---|---|---|
| 1 | U Aye Cho | Farmer |
| 2 | U Tin Shwe | Farmer |
| 3 | U Han Thein | Farmer |
| 4 | U Myint Han | Farmer |
| 5 | U Hla Thai | Farmer |
| 6 | U Aye Khaing | Farmer |
| 7 | U Hla Shwe | Farmer |
| 8 | U Aung Pwint Htet | Farmer |
| 9 | U Win Kyaw Aung | Farmer |
| 10 | U Than Htwe | Farmer |
| 11 | U Si Thu Lin | Farmer |
| 12 | U Kyaw Min | Farmer |
| 13 | U Saw Win | Farmer |
| 14 | U Win Soe | Farmer |
| 15 | U Kyaw Hlaing | Farmer |
| 16 | Daw San Yu May | Farmer |
| 17 | U San Maung | Farmer |
| 18 | U Myint Win | Farmer |
| 19 | U Than Oo | Farmer |
| 20 | U Thet Naing Oo | Farmer |
| 21 | U Khin Tun | Farmer |
| 22 | U Han Win | Farmer |
| 23 | U Tin Maung | Farmer |
| 24 | U Win Kyi | Farmer |
| 25 | U Aung Myint San | Farmer |

Annex II

**“Training of Nutrient Management, Heavy Metal Contamination and Soil and Water Sampling Techniques” Attendant Staff List**

Place-Kyaungggon Township, Ayeyarwady Region Date-5-6.3.2023

| No. | Name | Position |
|---|---|---|
| 1 | U Htet Kyaw Oo | Assistant Director |
| 2 | U Than Htike | Deputy Staff Officer |
| 3 | Daw Aye Aye Khaing | Deputy Staff Officer |
| 4 | U Sein Myint | Deputy Staff Officer |
| 5 | Daw Myint Myint Moe | Deputy Staff Officer |
| 6 | Daw Khin San Wai | Assistant Staff Officer |
| 7 | U San Win | Assistant Staff Officer |
| 8 | U Ye Htay | Assistant Staff Officer |
| 9 | Daw Phyu Hnin Phway | Deputy Assistant Staff Officer |
| 10 | Daw Hnin Pwint Lwin | Deputy Assistant Staff Officer |
| 11 | U Hein Zaw Htet | Deputy Assistant Staff Officer |
| 12 | Daw Hnin Wutt Ye | Deputy Assistant Staff Officer |
| 13 | Daw Su Ye Soe | Deputy Assistant Staff Officer |
| 14 | U Aung Myo Win | Deputy Assistant Staff Officer |
| 15 | U Aung Myint Swe | Deputy Assistant Staff Officer |

# "Training of Nutrient Management, Heavy Metal Contamination and Soil and Water Sampling Techniques" Attendant Farmers List

Place-Kyaunggon Township, Ayeyarwady Region Date-5-6.3.2023

| No. | Name | Position |
|---|---|---|
| 1 | U Aung Naing | Farmer |
| 2 | U Aung Thu | Farmer |
| 3 | U Tun Min Lat | Farmer |
| 4 | Win Hlaing | Farmer |
| 5 | U Kyaw Aye | Farmer |
| 6 | U Hla Htay | Farmer |
| 7 | U Myo Min Zaw | Farmer |
| 8 | Daw San Htay | Farmer |
| 9 | U Kyaw Win | Farmer |
| 10 | U Maung Maung Myint | Farmer |
| 11 | U Maung Maung Kyaw | Farmer |
| 12 | U San Win Maung | Farmer |
| 13 | U Myat Min | Farmer |
| 14 | U San Oo | Farmer |
| 15 | U Thet Wai | Farmer |
| 16 | U Taunt Tun | Farmer |
| 17 | U Soe Hlaing | Farmer |
| 18 | U Tin Than | Farmer |
| 19 | U Win Aung | Farmer |
| 20 | U Win Sein | Farmer |
| 21 | U Win Maung | Farmer |
| 22 | U Joesez | Farmer |
| 23 | U Thant Sin | Farmer |
| 24 | Daw Sayama | Farmer |
| 25 | U Aung Win | Farmer |
| 26 | U Myint Aung | Farmer |
| 27 | U Man Thin Aung | Farmer |
| 28 | U Myo Ko Ko Lin | Farmer |
| 29 | U Aung Kyaw Win | Farmer |

| | | |
|---|---|---|
| 30 | U Nay Lin Tun | Farmer |
| 31 | U Aung Lin Htwe | Farmer |
| 32 | U Shwe Tun | Farmer |
| 33 | U Kyaw Kyaw Naing | Farmer |
| 34 | U Moe Myint Aye | Farmer |
| 35 | U Soe Naing | Farmer |
| 36 | U Kyi Nyein | Farmer |
| 37 | U Tint Khine | Farmer |
| 38 | U Kyaw Naing | Farmer |
| 39 | U Kyaw Oo | Farmer |
| 40 | U Kyaw Kyi | Farmer |

# "Training of Nutrient Management, Heavy Metal Contamination and Soil and Water Sampling Techniques" Attendant Staff List

Place-Lewe Township, Nay Pyi Taw Region Date-5-6.6.2023

| No. | Name | Position |
|---|---|---|
| 1 | Daw Tin Mar Aye | Assistant Director |
| 2 | U Phone Kyaw | Assistant Director |
| 3 | U Tint Naing | Staff Officer |
| 4 | U Shwe Ko | Staff Officer |
| 5 | Daw Nilar Shein | Deputy Staff Officer |
| 6 | U Ye Min Tun | Deputy Staff Officer |
| 7 | U Myo Min Aung | Assistant Staff Officer |
| 8 | Daw Ohmar | Assistant Staff Officer |
| 9 | U Tun Thin | Deputy Assistant Staff Officer |
| 10 | U Phyo Wai Kyaw | Deputy Assistant Staff Officer |
| 11 | U Zin Wai Aung | Deputy Assistant Staff Officer |
| 12 | U Aung Kyaw Zaw | Deputy Assistant Staff Officer |
| 13 | Daw May Thu Zaw | Deputy Assistant Staff Officer |
| 14 | Daw La Pyae Win | Deputy Assistant Staff Officer |
| 15 | Daw Chan Myaw | Deputy Assistant Staff Officer |

Annex II

# "Training of Nutrient Management, Heavy Metal Contamination and Soil and Water Sampling Techniques" Attendant Farmers List

Place-Lewe Township, Nay Pyi Taw Region Date-5-6.6.2023

| No. | Name | Position |
|---|---|---|
| 1 | U Thein Myint | Farmer |
| 2 | Daw Mya Mya | Farmer |
| 3 | Daw San San WIn | Farmer |
| 4 | Daw Than Htay | Farmer |
| 5 | Daw Soe Soe Nwe | Farmer |
| 6 | U Aung Khaing | Farmer |
| 7 | U Myint Naing | Farmer |
| 8 | Daw Nwet Nwet | Farmer |
| 9 | U Phone Lone | Farmer |
| 10 | Daw Moe Moe | Farmer |
| 11 | U Thet Naing Win | Farmer |
| 12 | U Wai Zin Htwe | Farmer |
| 13 | U Ko Sit | Farmer |
| 14 | Daw Win | Farmer |
| 15 | Daw Aye Than | Farmer |
| 16 | Daw Khin Win | Farmer |
| 17 | U Zaw Naing Min | Farmer |
| 18 | U Min Khant Kyaw | Farmer |
| 19 | U Ye Lin Naing | Farmer |
| 20 | U Yan Aung | Farmer |
| 21 | U Myo Zaw Htet | Farmer |
| 22 | U Win Htwe | Farmer |
| 23 | U Moe Win | Farmer |
| 24 | U Pyae Sone Aung | Farmer |
| 25 | U Zin Maung Maung | Farmer |
| 26 | U Aung Zaw Myo | Farmer |
| 27 | U Kaung Htet Soe | Farmer |
| 28 | U Myint Oo | Farmer |

| | | |
|---|---|---|
| 29 | U Nyunt Shwe | Farmer |
| 30 | U Maung Sein | Farmer |
| 31 | U Kyi Lin | Farmer |
| 32 | U Myint Hlaing Oo | Farmer |
| 33 | U Aung Ko Ko | Farmer |
| 34 | U Zaw Naing Win | Farmer |
| 35 | Daw Myint Myint Win | Farmer |

Annex II

**"Training of Nutrient Management, Heavy Metal Contamination and Soil and Water Sampling Techniques" Attendant Farmers List''**

Place-Tatkon Township, Nay Pyi Taw Region Date-8-9.6.2023

| No. | Name | Position |
|---|---|---|
| 1 | U Zaw Min Oo | Deputy Staff Officer |
| 2 | Daw Moe Moe | Deputy Staff Officer |
| 3 | Daw Khin San Oo | Deputy Staff Officer |
| 4 | Daw May Thwin Oo | Deputy Staff Officer |
| 5 | Daw Mar Mar Myint | Assistant Staff Officer |
| 6 | Daw Hnin Thandar Hlaing | Assistant Staff Officer |
| 7 | Daw Ni NI Win | Assistant Staff Officer |
| 8 | Daw Mar Mar Aung | Assistant Staff Officer |
| 9 | U Kyaw Moe Aung | Deputy Assistant Staff Officer |
| 10 | U Htet Aung Hlaing | Deputy Assistant Staff Officer |

# "Training of Nutrient Management, Heavy Metal Contamination and Soil and Water Sampling Techniques" Attendant Farmers List

Place-Tatkon Township, Nay Pyi Taw Region Date-8-9.6.2023

| No. | Name | Position |
|---|---|---|
| 1 | U Maung Hla | Farmer |
| 2 | U Nyi NYi | Farmer |
| 3 | U Kyaw Wai | Farmer |
| 4 | U Thein Htay | Farmer |
| 5 | U Win Bo | Farmer |
| 6 | Daw Than Ngwe | Farmer |
| 7 | Daw Thida | Farmer |
| 8 | Daw Khin Swe Oo | Farmer |
| 9 | U Ye Lin Aung | Farmer |
| 10 | U Nay Win | Farmer |
| 11 | U Kyaw Ngwe | Farmer |
| 12 | U Aung Min | Farmer |
| 13 | U Than Hlaing | Farmer |
| 14 | U Myint Naing Oo | Farmer |
| 15 | U Than Myat Tun | Farmer |
| 16 | U Win Soe | Farmer |
| 17 | U Ye Naing Soe | Farmer |
| 18 | U Ta Yote | Farmer |
| 19 | U Than Oo | Farmer |
| 20 | U San Win | Farmer |
| 21 | U Arkar Phyo | Farmer |
| 22 | U Soe Hlaing | Farmer |
| 23 | U Nan Win Tun | Farmer |
| 24 | Daw Shan Ma | Farmer |
| 25 | Daw Kyu | Farmer |
| 26 | Daw Kyi Khaing | Farmer |
| 27 | Daw Yu Yu Shwin | Farmer |
| 28 | Daw Lin | Farmer |
| 29 | Daw Nan Myint Kyaing | Farmer |

| | | |
|---|---|---|
| 30 | U Myint Aung | Farmer |
| 31 | U Kyaw Win | Farmer |
| 32 | U Zaw Moe | Farmer |
| 33 | U Thein Swe | Farmer |
| 34 | U Ayar Lin | Farmer |
| 35 | U Myint Naing Oo | Farmer |
| 36 | U Than Myat Tun | Farmer |
| 37 | U Win Soe | Farmer |
| 38 | U Ye Naing Soe | Farmer |
| 39 | U Ta Yote | Farmer |
| 40 | U Than Oo | Farmer |

**Annex III**

**"Assessment of Heavy Metal Contamination in Soil and Water for Safety Crop Production in Myanmar" Project funded by MROK**

**"Training of Nutrient Management, Heavy Metal Contamination and Soil and Water Sampling Techniques" schedule**

<table>
<tr><td>Date /Time</td><td>8:30-9:00</td><td colspan="2">9:00-10:00</td><td>10:00-11:00</td><td>11:00-12:00</td><td rowspan="2">Lunch Break</td><td>13:00-14:00</td><td rowspan="2">Coffee Break</td><td>14:10-15:10</td><td>15:10-16:00</td></tr>
<tr><td></td><td>Session I</td><td colspan="2">Session II</td><td>Session III</td><td>Session IV</td><td>Session V</td></tr>
<tr><td>Day 01</td><td>Opening and Registration</td><td colspan="2">Dr. Cho Mar Htwe<br>Plant Nutrients, Soil fertility and Heavy metal</td><td>Dr. Khin Khin Mu<br>Integrated Nutrient Management</td><td>Ms Naing Naing Moe<br>Soil sampling techniques and its benefits</td><td colspan="2">Dr. Sein Sein Mu<br>Digital Survey Collection Methods (Koko Toolbox)</td></tr>
<tr><td>Day 02</td><td>Registration</td><td colspan="2">Dr. Khin Nyunt Yee<br>Systematic application of Herbicides, Pesticide and damages</td><td>Dr. Cho Mar Htwe<br>Green manuring and introduction of Green manure plants</td><td>Dr. Cho Mar Htwe<br>Organic compost making and benefits</td><td colspan="2">Dr. Wunna Htun GAP protocol for crop production</td></tr>
</table>



**Documentary Photo: Project Launch Meeting at Department of Agriculture (Hybrid Format)**




**Photo Documentary: Expert Meeting in Nay Pyi Taw**

**Photo Documentary: Soil and Water Sampling activity in Kyaungkone Township, Ayeyarwady Region**



**Photo Documentary: Soil and Water Sampling in Tatkon Township, Nay Pyi Taw**






Photo Documentary:  Socioeconomic Survey Activities in Ayawaddy Region






**Photo Documentary: Socioeconomic survey activities in Nay Pyi Taw Region**






**Photo Documentary: Training for farmers and staffs in Kyaunggon Township**

**Photo Documentary: Training for farmers and staffs in Yekyi Township, Ayawaddy Region**

**Photo Documentary: Training for farmers and staffs in Lewe Township**






**Photo Documentary: Training for farmers and staffs in Tatkon Township, Nay Pyi Taw**




**Photo: Computers and Materials**