Preliminary Site Assessment: Former Warehouses of Pesticides in the Tajikistan Republic

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ACRONYMS

ATSDR	*Agency for Toxic Substances and Disease Registry*
CAS No.	*Chemical Abstracts Service Registry Number*
CSM	*Conceptual site model*
DSA	*Detailed site assessment*
DDD	*dichlorodiphenyldichloroethane*
DDE	*dichlorodiphenyldichloroethene*
DDT	*p,p'-dichlorodiphenyltrichloroethane*
EPA	*United Sates Environmental Protection Agency*
FAO	*Food and Agriculture Organization of the United Nations*
GEMS	*Global Environment Monitoring System*
IARC	*International Agency for Research on Cancer*
ICPS	*International Programme on Chemical Safety*
ISS	*Initial site screening*
IUPCA	*International Union of Pure and Applied Chemistry*
JMPR	*Joint FAO/WHO Meeting on Pesticide Residues*
LOD	*Level of detection*
LMIC	*Low and middle income countries*
MAC	*Maximum Allowable Concentrations*
NGO	*Non-Governmental Organization*
NIST	*National Institute of Standards and Technology*
NOAEL	*no-observed-adverse-effect level*
NTP	*United States National Toxicology Program*
PTDI	*provisional tolerable daily intake*
PSA	*Preliminary site assessment*
POP	*Persistent organic pollutant*
RGVs	*regulatory guidance values*
TSIP	*Toxic Sites Identification Program*
UNEP	*United Nations Environment Programme*
USA	*United States of America*
WHO	*World Health Organization*

EXECUTIVE SUMMARY

The Toxic Sites Identification Program (TSIP) is an international effort led by Pure Earth to identify and assess contaminated land in Low and Middle Income Countries (LMIC). The activities of the program were designed to identify, communicate, and mitigate exposures at hazardous waste sites in LMIC to fulfill the following main program objectives:

1. Improve existing knowledge and gather critical data about the scope of toxic pollution and its human health impacts by expanding the TSIP;

2. Encourage national and international decision-makers to mainstream the issue of toxic pollution, chemicals and wastes and associated impacts on human health and the environment into development agendas through awareness-raising, presentation of scientifically-based evidence and encouraging action; and

3. Assist decision-makers and communities in select countries to mitigate the impacts of toxic pollution, chemicals and wastes on human health and the environment through training and capacity-building, and provision of technical expertise and support, for specific interventions that produce measurable reductions in exposure risk.

The initial steps of the process are to identify contaminated areas and assess existing health risks pursuant to a proprietary risk priorities algorithm. In 2018-2019 Pure Earth Blacksmith Institute and National Non-Governmental Agency (NGO) Peshsaf conducted over 80 assessments of contaminated sites in Tajikistan. As a result of this work, three sites were identified as priority areas where the health risks were high and risk reduction activities feasible. These sites include: pesticide burial in Sherobod, Dusti, Jami district; former pesticide storage in Beshkent, Istiklol Jamoat Nosiri Khusravsky district; and former pesticide storage in Sangob, Jamoat of the 20th Anniversary of Independence of Tajikistan, Kubodiyon district. The project team conducted Preliminary Site Assessments (PSA) at these locations to collect more detailed information about the nature of the contamination and existing health risks.

These sites are located in rural areas of the Khatlon Region situated in the south of Tajikistan. The contamination pattern, exposure pathways and main contaminants are similar in all three sites. Based on the results of the PSA, it was determined that all three of these areas are contaminated with 1,1,1-trichloro-2,2-bis(p-chlorophenyl) ethane (DDT) – a toxic carcinogenic and mostly discontinued pesticide. The list of secondary contaminants include toxic substances that contaminate commercial preparations of DDT or result from chemical transformation of DDT in soil: DDE (1,1-dichloro-2,2- bis(p-chlorophenyl) ethylene) and DDD (1,1-dichloro-2,2-bis(p-chlorophenyl) ethane). The national standard for DDT in Tajikistan is 0.1 mg/kg, the United States Environmental Protection Agency (USEPA) Regional Screening Level (RSL) for DDT in residential soil is 1.9 mg/kg. At these sites the

soil concentrations ranged from 13.9 to 2245 mg/kg and the average concentration was 596.2 mg/kg. The concentration of DDT in soils exceeded the baseline values of Tajikistan (0.1 mg/kg) in 139-22450 times. The USEPA RSL for residential soil (1.9 mg/kg) was exceeded by 7.3-1182 times.

The project team also assessed the area for heavy metals contamination, paying particular attention to lead, arsenic, thorium, and uranium; and found no significant concentrations of those toxic heavy metals. The results of sampling of the area for pesticides and heavy metals contamination were mapped.

The main source of contamination at these sites is DDT and soil contaminated with DDT and its derivatives. The DDT was formerly stored in warehouses located in each of the areas studied, and was buried or piled on the surface after the old pesticide storage buildings were demolished. Now, human exposure is possible, mainly through inhalation of dust and vapors and dermal contact, and the presence of DDT contamination may also prevent reuse of these sites for agriculture or construction of new housing.

As part of PSA process, the project team met with heads (hakims) of District Administrations and local administrations to discuss the findings and feasibility of risk reduction activities. The local administrators expressed support for the assessment activities and promised to help with the coordination and implementation of future risk reduction measures. The project team also interviewed local residents to find out about the contamination distribution patterns and known health impacts.

As a result of the PSA, the project team confirmed significant contamination of discontinued pesticides from limited sampling of the assessed sites and recommends to proceed with a more Detailed Site Assessment (DSA) in order to determine the magnitude of impacts, estimated volumes of contaminated materials and risk reduction alternatives.

INTRODUCTION

Pesticides Overview

Since before 2000 BC, humans have utilized pesticides to protect their crops. The first known pesticide was elemental sulfur dusting used in ancient Sumer about 4,500 years ago in ancient Mesopotamia. The Rig Veda, which is about 4,000 years old, mentions the use of poisonous plants for pest control.

The World Health Organization (WHO) (2017)[1] defined a pesticide as "*a chemical compound that is used to kill pests, including insects, rodents, fungi and unwanted plants (weeds)*." The Food and Agriculture Organization (FAO) of the United Nations defined a pesticide as "*any substance or mixture of substances intended for preventing, destroying, or controlling any pest, including vectors of human or animal diseases, unwanted species of plants or animals causing harm during, or otherwise interfering with, the production, processing, storage, or marketing of food, agricultural commodities, wood and wood products, or animal feedstuffs, or which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies*."

Pesticides can be classified by target groups as acaricides, avicides, bactericides, herbicides, fungicides, insecticides, repellents, virucides, and so on. According to the chemical compositions of the active ingredients, pesticides can be categorized into four main groups: carbamates, organochlorines, organophosphorus, and pyrethrin and pyrethroids. WHO (2009)[2] classified pesticides by hazard as an extremely hazardous pesticide, a highly hazardous pesticide, a moderately hazardous pesticide, a slightly hazardous pesticide, and a pesticide which is unlikely to present an acute hazard. In addition, based on the mode of formulation, pesticides can be classified as emulsifiable concentrates, wettable powders, granules, baits, dust, and fumigants[3].

Organochlorine pesticides are chlorinated hydrocarbons used extensively from the 1940s through the 1960s in agriculture and mosquito control. Representative compounds in this group include DDT, methoxychlor, dieldrin, chlordane, toxaphene, mirex, kepone, lindane, and benzene hexachloride. Because of the complex chemical structures and the chemical complexity of these pesticides and their active ingredients, these pesticides are often regulated by their trade names instead of the chemical nomenclature conventions. For example, the National Institute of Standards and Technology (NIST) (2011)[4] listed 120 names for the pesticide "Lindane", which include 30 chemical nomenclature names and 90 other trade names. Even worldwide jurisdictions have regulated pesticides by their local trade names in foreign languages, which has made it difficult to identify pesticides by their "names". The Chemical Abstracts Service Registry Number (CAS No.) developed by the NIST and the common name developed by the International Union of Pure and Applied Chemistry (IUPCA) are commonly used as reference. Unfortunately, the CAS No. is not available for most worldwide jurisdictions beyond Europe and North America.

Pesticide Impacts

The impact of pesticide residues on human health is a worldwide problem, as human exposure to pesticides can occur through ingestion, inhalation, and dermal contact. Regulatory jurisdictions have promulgated the standard values for pesticides in residential soil, air, drinking water, and agricultural commodity for years. Until now, more than 19,400 pesticide soil regulatory guidance values (RGVs) and 5,400 pesticide drinking water maximum concentration levels (MCLs) have been regulated by 54 and 102 nations, respectively.

Pesticides are broadly applied in numerous agricultural, commercial, residential, and industrial applications to control and kill pests. They help society fight disease and increase agricultural productivity; however, pesticides can be transported into the air, water, soil, and biomass after numerous applications and can cause risks to the ecosystem and to human health. The impact of pesticide residues on human health is a worldwide problem, as human exposure to pesticides can occur through the ingestion of pesticide-contaminated water, food, or residential surface soil, the inhalation of pesticide-contaminated air, soil dust, or industrial vapor, and dermal contact with pesticide-contaminated water (*e.g*., swimming, showering, or raining), air, agricultural commodities, or soil. Bioaccumulation, for example, is the gradual accumulation of substances, such as pesticides (*e.g.,* DDT), or other chemicals in an organism. Bioaccumulation occurs when an organism absorbs a substance at a rate faster than that at which the substance is lost by catabolism and excretion.

Worldwide jurisdictions have been working on regulating pesticide standard values for residential surface soil, residential air, drinking water, surface water, groundwater, and food for years.

Pesticides in Soil

Pesticide soil regulatory guidance values (RGVs) are applied by worldwide soil jurisdictions to control pesticide pollution in residential surface soil. Pesticide soil RGVs specified the maximum amount of a pesticide which might be present in the soil without prompting regulatory responses, such as surface or groundwater contamination by the transport of pesticides from surface soil, ecological risk, and adverse human health effects by exposure to soil pesticides. The most concerned and conservative pesticide soil RGVs are provided for residential surface soil, where children can be exposed to soil pesticides by the ingestion of soil, the inhalation of soil dust, or dermal contact. Children are especially vulnerable to pesticides because their bodies are still developing, and their diets and activities - such as playing on pesticide-treated lawns or eating a lot of fruits with pesticide residue - can result in high exposures.

Although many worldwide regulatory jurisdictions have provided the RGVs in soil to protect human health, there is a lack of agreement on the pesticides that need to be regulated, as well as the magnitude of the pesticide soil RGVs that should be applied to a certain pesticide. For some of the most frequently regulated pesticides, the RGVs vary to above six orders of magnitude (*i.e.,* 1,000,000)[5]. This variability implies that worldwide, soil regulatory jurisdictions have hugely different views on the criteria, which cause significant human health risks by residential surface soil pesticides. Other studies have also investigated soil RGVs, but have had their evaluations restricted to less-extensive sets of jurisdictions, such as the United States and European nations[6,7,8,9,10,11,12].

Pesticides in Air

Pesticides can exist in residential air by the evaporation of volatile and semi-volatile pesticides, such as organochlorine pesticides, from crops and residential surface soil. In addition, pesticides can be blown away from agricultural fields by the wind, and some fumigants (*e.g.,* bromomethane) are released into the air in a gaseous form. Therefore, the regulation of pesticide standard values in the residential air is necessary to control human health risks through inhalation and dermal contact exposures, especially for volatile and semi-volatile pesticides. However, few worldwide jurisdictions have regulated pesticide air standard values, which means that people around the world are probably not protected by the pesticide air regulations, especially for some farmers and workers who frequently work in the agricultural field.

DDT – General Description

Organochlorine pesticides are chlorinated hydrocarbons used extensively from the 1940s through the 1960s in agriculture and mosquito control. Representative compounds in this group include **DDT**, methoxychlor, dieldrin, chlordane, toxaphene, mirex, kepone, lindane, and benzene hexachloride. The term DDT refers to *p*,*p*'-DDT, or *p*,*p*'-dichlorodiphenyltrichloroethane. DDT, prepared by the reaction of chloral with chlorobenzene in the presence of sulfuric acid, was first made in 1874; and its insecticidal properties were discovered in 1939 by a Swiss chemist, Paul Hermann Müller. DDT (dichloro-diphenyl-trichloroethane) is considered one of the first of the modern synthetic insecticides.

DDT is applied as a dust or by spraying its aqueous suspension. The compound's structure permits several different isomeric forms, such as *o*,*p*'-DDT. The term DDT is also applied to commercial products consisting predominantly of *p*,*p*'-DDT, but also containing smaller amounts of other compounds, including *p*,*p*'- and *o*,*p*'-DDD (dichlorodiphenyldichloroethane) and *p*,*p*'- and *o*,*p*'-DDE (dichlorodiphenyldichloroethene)[13]. Its CAS No. is 107917-42-0 and has a molecular formula of $C_{14}H_9C_{l5}$. All DDT isomers are tasteless, almost odorless solids. Its physicochemical properties include:

- Physical state White, crystalline solid
- Melting point 108.5–109 °C
- Vapor pressure 2.53 × 10-5 Pa at 20 °C

- Solubility in water Highly insoluble (1 μg/liter)
- Log octanol–water partition coefficient 7.48

Major uses of DDT

DDT is a non-systemic contact insecticide with a broad spectrum of activity. Growers used DDT on a variety of food crops in the United States and worldwide. Some of the crops were beans, cotton, soybeans, sweet potatoes, peanuts, cabbage, tomatoes, cauliflower, brussel sprouts, corn, and other crops. DDT was also used in buildings for pest control.

It was banned in several countries in the early 1970s because of ecological considerations, and many other countries have more recently restricted or banned its use except when it is needed for the protection of human health. Despite a ban on sales, organochlorines may still be found in storage in many countries such as Tajikistan; thus, exposure is still possible. DDT is still used in some countries for the control of vectors that transmit yellow fever, sleeping sickness, typhus, malaria and other insect-transmitted diseases.

DDT Persistence

DDT was designated as a persistent organic pollutant (POP) in 1997 by the Governing Council of the United Nations Environment Programme[14]. Pesticide applicators are exposed primarily to *p*,*p*'-DDT, whereas it is the *p*,*p*'-DDE metabolite to which the general population is exposed in the diet or drinking-water.

DDT and its metabolites are persistent in the environment and resistant to complete degradation by microorganisms, although photochemical degradation does occur. The persistence of DDT is substantially lower in tropical climates than in temperate ones (a few months compared with years)[13]. DDT and its metabolites are readily adsorbed onto sediments and soils, which can act both as sinks and as long-term sources of exposure. Because of its strong tendency to be adsorbed onto surfaces, most DDT that enters water is and remains firmly attached to soil particles. If it does find its way into water, it is gradually lost by adsorption onto surfaces[13].

In soils, DDT is immobile under aerobic conditions with a mean half-life ranging from 2 to 15 years[15,16,17,18,19]. DDT is metabolized by microbial systems in soils and is broken down into DDE and DDD. Significant degradation has been demonstrated in soils under anaerobic conditions, while little or no degradation was observed under aerobic conditions[20]. Biodegradation, however, is highly variable and influenced by the populations of required microorganisms. Various amendments to soils such as energy and carbon sources, were shown to increase degradation under anaerobic but not aerobic conditions[20,21]. DDT has been shown to readily degrade in certain flooded soils[22]. DDT is apparently co-metabolized by microorganisms and is not used as a sole carbon source. Products of biodegradation include DDD and DDE and occasionally DBP (4,4'-dichlorobenzophenone).

The physical and chemical properties of DDT and its metabolites enable these compounds to be taken up readily by organisms from the surrounding medium and from food. In aquatic organisms, uptake from water is generally more important, whereas food is the major source for terrestrial fauna. High lipid solubility and low water solubility lead to the retention of DDT and its stable metabolites in fatty tissue. In general, organisms at higher trophic levels tend to contain more DDT-type compounds than those at lower ones. These compounds can be transported around the world in the bodies of animals, as well as in ocean and air currents.

In the United States, populations of bald eagles and other raptors crashed when DDT thinned their eggs, killing their embryos. The pesticide, known for accumulating in food webs and persisting in soil and river sediment, was banned in the United States in 1972. Studies in animals have also shown that oral exposure to DDT can cause liver cancer.

DDT is classified as "moderately toxic" by the US National Toxicology Program (NTP) and "moderately hazardous" by WHO, based on the rat oral LD 50 of 113 mg/kg. Indirect exposure is considered relatively non-toxic for humans. The International Agency for Research on Cancer (IARC) classified DDT as Group 2A “possibly carcinogenic to humans”. EPA has determined that DDT, DDE, and DDD are probable human carcinogens as of January, 2015.

Current concerns surrounding DDT are that it is an endocrine disruptor. Endocrine disruptors are chemicals that can interfere with endocrine (or hormone) systems at certain doses. These disruptions can cause cancerous tumors, birth defects, and other developmental disorders. Any system in the body controlled by hormones can be derailed by hormone disruptors. A wide and varied range of substances are thought to cause endocrine disruption. Chemicals that are known endocrine disruptors include diethylstilbestrol (the synthetic estrogen DES), dioxin and dioxin-like compounds, polychlorinated biphenyls (PCBs), **DDT**, and some other pesticides.

Pesticides in Tajikistan

Before the collapse of the Soviet Union, pesticides and other chemicals were actively used in Tajikistan’s agriculture. The application of different pesticides was often done without proper adherence to the existing rules and standards and without consideration of the climatic conditions in different areas. This resulted in some serious problems, including:

- poisoning people;
- death of wild and domestic animals;
- decrease of biodiversity;
- accumulation of pesticides in food chains;
- disruption of natural control of pests;
- decrease of the quality of soils due to accumulation of pesticides;
- contamination of water

The range of pesticides used in Tajikistan included the following POPs: aldrin, dieldrin, heptachlorine, endrin, hexachlorinebenzene, toxaphene, chlordane, DDT, endosulphane, and lindane. On average, about 14 thousand tons of pesticides were brought to Tajikistan every year. The share of DDT constituted from 33 to 80% of the total volume of pesticides. About 90 thousand tons of DDT were brought to Tajikistan during the period of active use of this insecticide.

In 1970, by the decree of the Minister of Health of the Soviet Union, application of DDT was banned in agriculture and, in 1987. DDT was banned for use to control vector-borne diseases. In the 1980s and through the beginning of 1990s, the use of other pesticides-POPs was also banned. Despite the ban, the remaining pesticides were still used, though in much smaller volumes.

Currently, the threat of obsolete pesticides to the health of people and the environment in Tajikistan still exists. During the Soviet time, the amount of pesticides brought to Tajikistan exceeded actual application needs by 1.5-2 times. As a result, excessive volumes of pesticides were accumulating in multiple storages and distribution centers of “Tajikselkhozkhimiya” Republican Service. Because there were so large volumes of unused pesticides, various violations occurred: pesticides were distributed to individuals for uncontrolled use in their gardens, some pesticides were dumped in municipal landfills or secretly buried. In the 2000s and because of small supplies of pesticides to Tajikistan, the existing volumes of obsolete pesticides were used again in agriculture. People particularly preferred using DDT and excavated the waste chemical from the Vakhsh polygon, where more than 9 thousand tones of DDT were buried. The customs of Tajikistan registered some cases of illegal import of DDT, including the case of bringing 7 tonnes of DDT from Uzbekistan.

Today, agriculture is an important part of Tajikistan economy, generating about 24.2% of GDP (2015). The total area of land used for growing various crops exceeds 900 thousand hectares. Much attention was also paid to the agricultural sector while Tajikistan was part of the USSR. In Tajikistan there were significant areas of agricultural land for growing crops, especially cotton, and millions of rubles were spent on building infrastructure, as well as providing the industry with agrochemicals and pesticides. The development of agriculture, and, above all, cotton growing, in Tajikistan was closely linked to the widespread use of pesticides to control agricultural pests, plant diseases, and weeds.

The Toxic Sites Identification Program (TSIP) Initiative

Because of the cotton industry developed during the Soviet era, independent Tajikistan is currently facing a legacy of a number of past unresolved issues related to pollution from obsolete pesticide. Currently, there are many private homes built in close proximity to former pesticides depots and large areas of pesticide-contaminated territory. The problem of obsolete pesticides and their storage has become one of the priority environmental problems in the Republic of Tajikistan.

The local Tajik NGO Peshsaf together with Pure Earth/Blacksmith Institute, leveraged the financial support of USAID and the European Union, to conduct a study of polluted sites in the Republic of Tajikistan and identify areas that should be assessed and possibly cleaned in order to reduce the existing health risks to people.

The project team performed 85 Initial Site Assessments (ISS) in the period from February 2019 to June 2019. In this work, Peshsaf and Blacksmith Institute/Pure Earth had many partners - non-governmental organizations based in rural areas: Arzing, Zanoni Shark, Madad, Mokhi Munir, Navzamin, Rohnamo, Ruhafzo, Rushdi Dier, Sapeda, Sadoi Kukhsor “Farodis”, “Eleler.” This work was closely coordinated with the Committee for Environmental Protection under the Government of the Republic of Tajikistan. The assessed sites are located in the regions of Khatlon, Sughd, and the Region of the Republican Subordination. Most sites are the locations of former storages of obsolete pesticides, mainly DDT. The collected ISS data were uploaded to the TSIP database.

Based on the results of ISS work, the project team identified 3 priority sites with risk to the health of local residents. These sites were studied in more detail and the findings are presented in this Preliminary Site Assessment report.

SITE DESCRIPTION

The sites are located in the Khatlon Region, the most densely populated part of the Republic of Tajikistan (Figure 1). Khatlon is located in the southwest of Tajikistan between the Gissar Range in the north and the Pyanj River to the south. The Khatlon Region borders Afghanistan in the south and southeast and Uzbekistan in the west. The capital of the region is the city of Bokhtar, formerly known as Kurgan-Tyube.

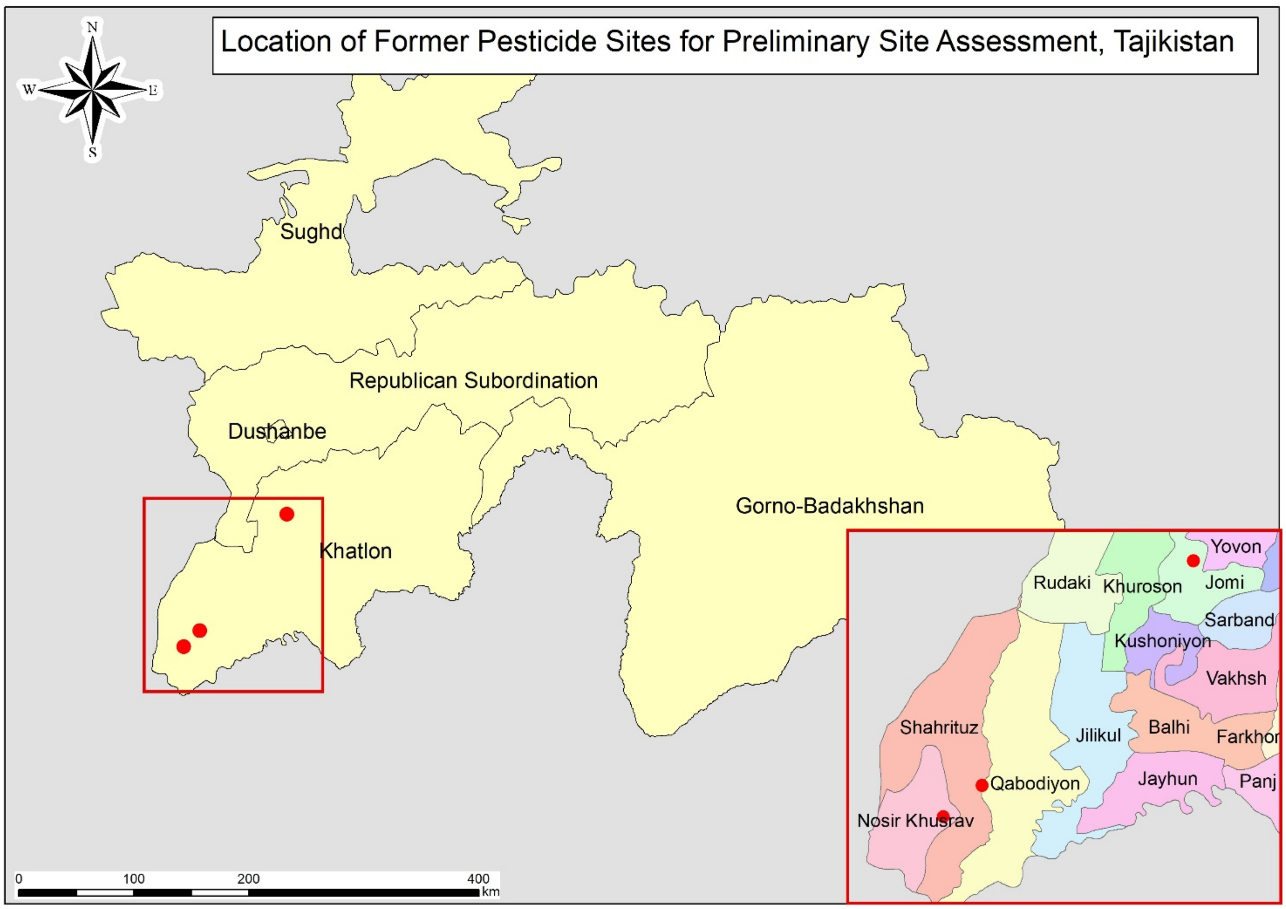

Figure 1. Location of Assessed Sites in Khatlon Region

The Khatlon Region covers an area of 24,800 square kilometers and consists of 24 districts. Fourteen of the districts are located in the western part of Khatlon and ten in the eastern part. The total population of the region in 2018 was 3,198,500. Agriculture is the main industry of the Khatlon Region.

Climate

The climate of Tajikistan is continental, subtropical and semi-arid, but the climatic conditions vary depending on altitude and geographical features. In the lowlands, the summers are warm and winters are moderately cold. The surrounding mountainous areas of the Western Pamir are also characterized by a dry climate, moderately warm summers and moderately severe winters.

The climate of the Khatlon region is continental. Compared to other regions, Khatlon is considered the hottest, especially the areas of Shartuz and Beshkent. The summer in the lowlands is very hot and arid, and the air temperature may reach +50° C and the top soil temperature may reach +70° C. The winter in the plains of Khatlon is mild. In the mountains, the temperatures may reach -35° C in wintertime. The Khatlon Region receives significantly less precipitation than the central parts of the country, and most of the precipitation falls mainly from October to March in the form of rain and snow. Snow falls mainly from mid-December to mid-February and rain falls from March to mid-May. Snow cover rarely reaches a depth of more than 10 cm and melts very quickly. The summers are very dry. The period from June to October has the least amount of precipitation. The total average annual precipitation registered at the Farkhor weather station is about 125 mm, in Hamadoni it ranges from 70 mm to 160 mm, and in Kulyab it is 468.4 mm (Table 1). These areas are also prone to the highest risk of natural disasters, such as earthquakes, which can cause landslides, mudflows, floods, and snow avalanches. These phenomena are considered when planning and building infrastructure.

Table 1. Main climatic characteristics of Khatlon Region

Outside temperature	Minimum temperature	-25° C
	Maximum temperature	+45 ° C
	Average daily temperature	+35 ° C
	Average nightly temperature	+16 — +17° C
Minimum/maximum topsoil temperature	-25 — +70° C	
Relative humidity	January - 80%, July -40%, and very dry	
Average precipitation	from100-200 mm and from 400 to 800 mm.	
Number of days of fog and cloud	About 100 days	
Maximum solar radiation	From 2,800 to 3,000 hours	
Maximum soil temperature	Greater than 36° C	
Ground temperature	From 32°C to 36°C and can be even hotter in July	
Elevation	Below 1000 meters	
Average wind speed	Under 2.1 meters/second	

Hydrology

The main rivers in the Khatlon Region are located in the valleys, and numerous small tributaries provide water from nearby mountains. These tributaries have good water quality, but many of them dry out during the summer months.

The largest mountain reservoirs (for example, Nurek) and the waters flowing downstream usually have good water quality and low sediment and pollutant content. Irrigation channels and valley rivers flow through agricultural land and settlements, and because of this, they contain a lot of sediments and suspended particles, especially during snowmelting and during the rainy season in the fall.

Soil and geology

The topography of the Khatlon Region is mainly characterized by plains and foothills with moderate slopes. The altitude ranges from 400 m to 1000 m in Kulyab District and from 300 m to 450 m in the rest of Khatlon Region.

The geological composition of Khatlon Region includes Cenozoic and mainly Miocene sedimentary rocks, consisting of thick blocks of proximal braided river sediments in large river plains. As a result of subsequent folding, a northeast-southeast-orientated relief of mountains and valleys was formed. Later, the valleys were filled with erosion deposits and proximal large river deposits. The Cenozoic rocks include evaporation layers (formed as a result of evaporation of a reservoir), which in many places degrade water quality. Natural geological salts and soluble minerals from sedimentary deposits are also common in this part of the Tajikistan. High mineralization is typically found in groundwater wells, but can also pollute surface waters.

The soil profile in Khatlon Region is mostly loess, sandy loam and loamy, sometimes rocky, soil formed by wind erosion in arid or semi-arid areas. The soils are brown-gray, light gray, and gray (Kulyab and Pyanj districts). The humus layer of loess and loamy sands is quite fertile and allows agricultural development. To use these soils for agriculture it is necessary to apply mineral fertilizers and supply irrigation.

Land use

In the valleys of the Khatlon Region, there are large-scale irrigated fields that receive water from the main rivers. Surface irrigation is mainly used for cotton, which requires large quantities of water. The issue with irrigation in this area is that wastewater usually returns back to the river. As the water moves across the fields, it gathers up agrochemicals, salts and sediments and washes them away from the fields. The deterioration of water quality in this area led to uncontrolled excess irrigation, an increase in groundwater levels, waterlogging, and the salinization of soils. The largest irrigated lands are located in Bokhtar District, receiving water from the Vakhsh River,. The towns of Kulyab, Vose and Guliston use water from the Kyzulsu River. Between the two main irrigated plains there are large-scale non-irrigated areas. In some areas, for example in Nurek, it rains about 1000 mm per year, and the high precipitation allows for the growth of crops. Only about 500 mm of precipitation falls in the southern part of Khatlon Region, and irrigation there is absolutely necessary for cultivating the land. Beyond the growth of crops, the arid mountain areas in the region are used for grazing.

Pesticide burial in the village of Sherobod, Jamoat Dusti, Jami district, TJ-7582

This pesticide burial is located on the outskirts of Sherobod village, Dusti Jamoat of Jami District in the Khatlon Region. The site is next to the road leading from the Sherabad village to the Galaba village. The distance to the district center is 17 kilometers.

At the end of the 1980s, more than 20 tons of toxic chemicals (bags and metal containers) of the former Ilyich state farm were buried about 100 meters away from the end of the village. As reported by local residents, the pesticides were buried at the depth of up to 4 meters, the total area of the contaminated zone is 16 sq. meters. The burial is located about 20 meters above the valley of the Shurchasoy River. The depth to groundwater is approximately 120 meters.

Until 1995, the residents of Sherobod village did not know about the pesticides buried in the area. The pesticides were discovered accidentally when a road was built through an area near the village of Galaba. Since that time, some local residents have engaged in digging up pesticides and using them. Some residents have also sold pesticides to farmers. The soil at the burial site is visually contaminated and there is a strong chemical smell. The site is also easily accessible to human and animal receptors.

The burial and the adjacent area are currently used as a pasture for livestock. The pesticides may accumulate in the bodies of farm animals, the products of which people eat. distance to the residential area is 100 meters.

The contaminated dust is carried with the wind, which may contaminate areas nearby. People passing through the area may inhale pesticide vapors. The soil from the contaminated area may also get washed by rainwater to the Shurchasoy River which flows into the Yavansu River, the right tributary of Vakhsh River. The contamination from the site could reach the river in case of significant erosion.

The main source of contamination at the site is the volume of buried pesticides. The people who may dig up the pesticides are at risk of exposure from dermal contact and inhalation of vapors. The animals grazing at the site are also exposed to pesticide vapors and contaminated dust.

Figure 2. Burial place in Sherobod

Table 2. Description of defined sectors in Sherobod

Sector Label	Description	Significance
1	Former warehouse/burial area	Obsolete pesticides are stored there
2	Residential area	New village and more than 30 families live within 100 meters

Former pesticide storage in Beshkent (Komsomol), Istiklol Jamoat in Nosiri Khusravsky District, TJ-7522

This site is located in the Nosiri Khusravsky administrative district in the Khatlon region of the Republic of Tajikistan. In the past, the warehouse was located away from the residential area and close to agricultural fields.

However, since 1991, there was increased development for the needs of the local people. The land with abandoned facilities of Tajikselkhozkhimiya was privatized and sold. Some residential houses were built near the area contaminated with pesticides.

The former pesticide warehouse on the property is completely destroyed. The walls were taken apart. The land is in violation of proper procedures for demolition/decommissioning and was given to some individuals for construction of houses. The contaminated soil from the warehouse is distributed around the area.

Near the site, there is a small irrigation channel which could contain some pesticides. This water serves as a drinking source for domestic animals. The groundwater level is at the depth of 8 meters.

The climate is dry and powdered pesticides mix with dust carried by the wind. Pesticides vaporize when the temperatures of outside air are high, especially in the summer. This causes the issue of strong smell and breathing problems for people living nearby. Local children are especially exposed to breathing the vapors and inhaling dust when playing outside.

The main sources of contamination at the site are the remains of the former storage building and the pile of soil and pesticides situated by the road. The local residents and their animals come in direct contact with contamination. The contaminants may spread to the neighboring area with wind carrying contaminated dust because it is an open area and the amount of annual precipitation is very small. The temperature of topsoil in July-August may reach 70^0 C (158^0F) which increases the volatilization of DDT. [23] The high temperatures or air and soil in the summer result in increasing the concentration of DDT vapors breathed by people passing the area.

Table 3. Description of defined sectors in Beshkent

Sector Label	Description	Significance
1	Former warehouse	Obsolete pesticides are stored there
2	Residential area	2 houses were built in the area and 5 more are scheduled to be built soon

Figure 3. Former storage of pesticides in Beshkent

Former pesticides storage in Sangob, Jamoat of the 20th Anniversary of Independence of Tajikistan, Kubodiyon District, TJ-7561

The warehouse ceased to function in 2000 and was destroyed. Only a part of the wall remained from the building. Near this wall there is a pile of soil and pesticides. The pile has a strong distinctive pesticide smell.

The nearest local houses are located 10 meters from the former warehouse. About 30 people live in them (of which 15 are children). A dry mixture of pesticides and dust is carried by the wind, coming in contact with people. Animals graze in the area. The access to the territory of the former warehouse is completely open, and children play there.

To the south of the former storage area there is a rice field and irrigation channel.

The groundwater level is at the depth of 10 meters.

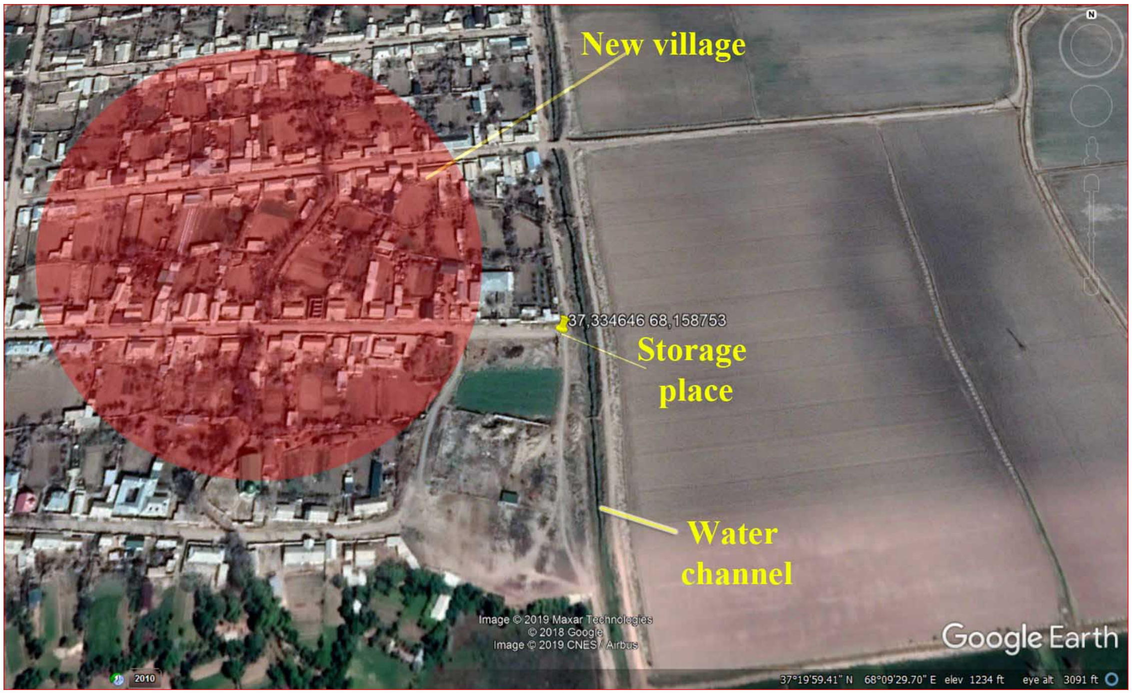

Figure 4. Former storage of pesticides in Sangob, Kubodiyon District

Table 4. Description of defined sectors in Sangob

Sector Label	Description	Significance
1	Former building of warehouse	Obsolete pesticides are stored there
2	Residential area	New village and about 20 new houses around a site

SAMPLING APPROACH

Each site was divided into sectors, which included the territory directly near the warehouses, the burial area and the zone where people live. At each site, 2 target samples and 1 composite sample were gathered.

The composite sample included from 4 to 10 samples of surface soil from the residential sector in an attempt to more broadly cover residential exposure to surface soils. The composite sample was collected in one container and thoroughly mixed. The number of samples at each site were purposely restricted in an effort to simply answer the question regarding the presence/absence of pesticide impact, and to identify the magnitude of such impact.

Sample Collection Procedure:

The person collecting the sample wore a clean pair of disposable gloves at each sample location. The soil sample was well mixed and free of stones and debris. A pre-cleaned trowel or spoon was used to collect the sample and place it into the sample container recommended by the laboratory.

To reduce volatilization, the sample container was filled to the top (if using a sample jar or bottle), or was wrapped with no air space (if using a plastic zip-type bag). A sampling assistant wrote a unique sample number and date/time of sample collection on each sample container using waterproof ink.

The sampling assistant determined the coordinates of each sample location with a global positioning system (GPS). The coordinates were either labeled with the sample number in the instrument digital log, or were recorded in the field notebook along with the sample number, whichever method is most convenient and is guaranteed to preserve the information. The sample information was recorded in the sample log.

Each sampling trip was preceded with some planning and coordination. Site location, NGO partner coordination, community/regulatory engagement, laboratory selection and communication, and field mobilization were all considered in advance.

A minimum of two people were assigned to a field team. In addition to safety concerns, the process of collecting the samples, labeling the containers and completing the field records is much easier if more than one person is present.

Sampling equipment was selected based on the type of sample to be collected, the analytes of interest, and the geology of the region (clayey and rocky). Sampling locations were selected such that a representative portion of the soil was collected with minimal disturbance. Locations where natural vegetation was deemed to be stressed or dead and/or areas that had surficial soil staining may be indicative of improper waste disposal practices and were specifically targeted. Precleaned equipment was brought to the field and all sample containers and lids were inspected for flaws (cracks, chips, etc.) before use.

Attention to prevent cross contamination and contamination of the environment when collecting samples was followed. Samples were collected from the least contaminated sampling locations (or background sampling location) to the most contaminated sampling location. Samples suspected of containing high concentrations of contaminants were isolated and placed in plastic bags immediately after collecting and labeling,

When composite sampling was performed, sampling points from which to collect each aliquot were selected; equal aliquots (same sample size) from each location were placed in a properly cleaned container. The container was properly labeled and identified in the appropriate field notes so that the laboratory was aware that the sample is a composite sample and that it must be mixed prior to analysis.

Latex Gloves were worn to protect the sample collector from potential exposure to sample constituents and to minimize accidental contamination of samples by the collector. All activities related to a sampling event, including sample collection, equipment calibration, equipment cleaning and sample transport were documented.

Additional sampling was conducted with portable X-ray fluorescence (XRF) analyzer to evaluate heavy metals contamination. The site was divided into cells 100 square meters each and the samples were taken in the center of each cell or as terrain or other features of the site permitted.

ANALYTICAL RESULTS AND INTERPRETATION

The soil samples were analyzed for concentrations of DDT, DDE, DDD, and lindane by the certified laboratory of the Agrophysics Science Institute, St-Petersburg, Russia. The concentration of DDT in soils exceeded the baseline values of Tajikistan (0.1 mg/kg) by 139-22,450 times. The regional soil level (RSL) for residential soil (1.9 mg/kg) was exceeded by 7.3-1,182 times, for industrial soil (8.5 mg/kg) – by 1.6 – 264 times[24,25,26]. These concentrations indicate high contamination of DDT and its metabolites. The summary statistics are presented in Table 5. The concentrations of DDT are shown below on Figures 5-7. The tables with raw data are presented in Appendix B.

With regards to heavy metals, the project team considered Regional Screening Levels (RSL) of the United States Environmental Protection Agency and Maximum Allowable Concentrations (MAC) adopted in Tajikistan and Russia. The following standards exist for most toxic heavy metals found in assessed sites: Arsenic (As inorganic) RSL for residential soils – 0,68 mg/kg (RSL), for industrial soils – 3 mg/kg, MAC – 2 mg/kg; Lead (Pb) RSL for residential soils – 400 mg/kg, for industrial soils – 800 mg/kg, MAC – 32 mg/kg; Uranium (U) RSL for (Soluble Salts) for residential soils – 16 mg/kg, for industrial soils – 230 mg/kg.

The collected data suggests that the levels of Arsenic are generally higher than the existing standards. But this could be related to naturally high background concentrations of Arsenic in the region. The concentrations of uranium are generally close to the standards for residential soil and much below the standard for industrial soil. No significant Lead contamination was found. The results of the conducted survey suggest that arsenic contamination should be considered and more information should be obtained about the background levels of arsenic in the region. The summary statistics are presented in Table 5.Figures 8-18 show the concentrations of arsenic, uranium and lead found in topsoil using the XRF-analyzer. The table with raw data is presented in Appendix B.

Table 5. Statistical summary of analytical results

Contaminant	No. of samples	Mean mg/kg	Median mg/kg	Range mg/kg	Lower Confidence Interval	Upper Confidence Interval (95%)
Sherobod						
Pb	33	46,24	36,00	16-194	34,46	58,02
As	33	11,52	0,00	0-113	3,55	19,48
Th	33	6,61	0,00	0-21	4,14	9,07
U	33	0,48	0,00	0-16	0	1,44
DDT	3	930,67	479,00	68-2245	0	2239,51
DDD	3	348,33	190,00	36-819	0	817,74
DDE	3	5,48	5,35	4,93-6,17	4,77	6,20
Beshkent						
Pb	38	11,18	13,00	0-32	8,10	14,26
As	38	3,87	0,00	0-18	2,07	5,66
Th	38	6,03	9,00	0-17	4,08	7,97
U	38	7,82	0,00	0-52	2,99	12,65
DDT	5	144,78	29,90	15,3-599	0	367,65
DDD	5	46,86	11,90	8,6-190	0	117,02
DDE	5	6,66	0,99	0,49-29,6	0	17,90
Sangob						
Pb	17	24,76	26,00	10-39	21,21	28,32
As	17	3,82	0,00	0-31	0	7,76
Th	17	6,82	0,00	0-22	3,07	10,58

U	17	4,65	0,00	0-21	0,97	8,32
DDT	3	638,97	323,00	13,9-1580	0	1577,60
DDD	3	285,17	200,00	9,5-646	0	654,84
DDE	3	4,72	1,48	0,37-12,3	0	12,17

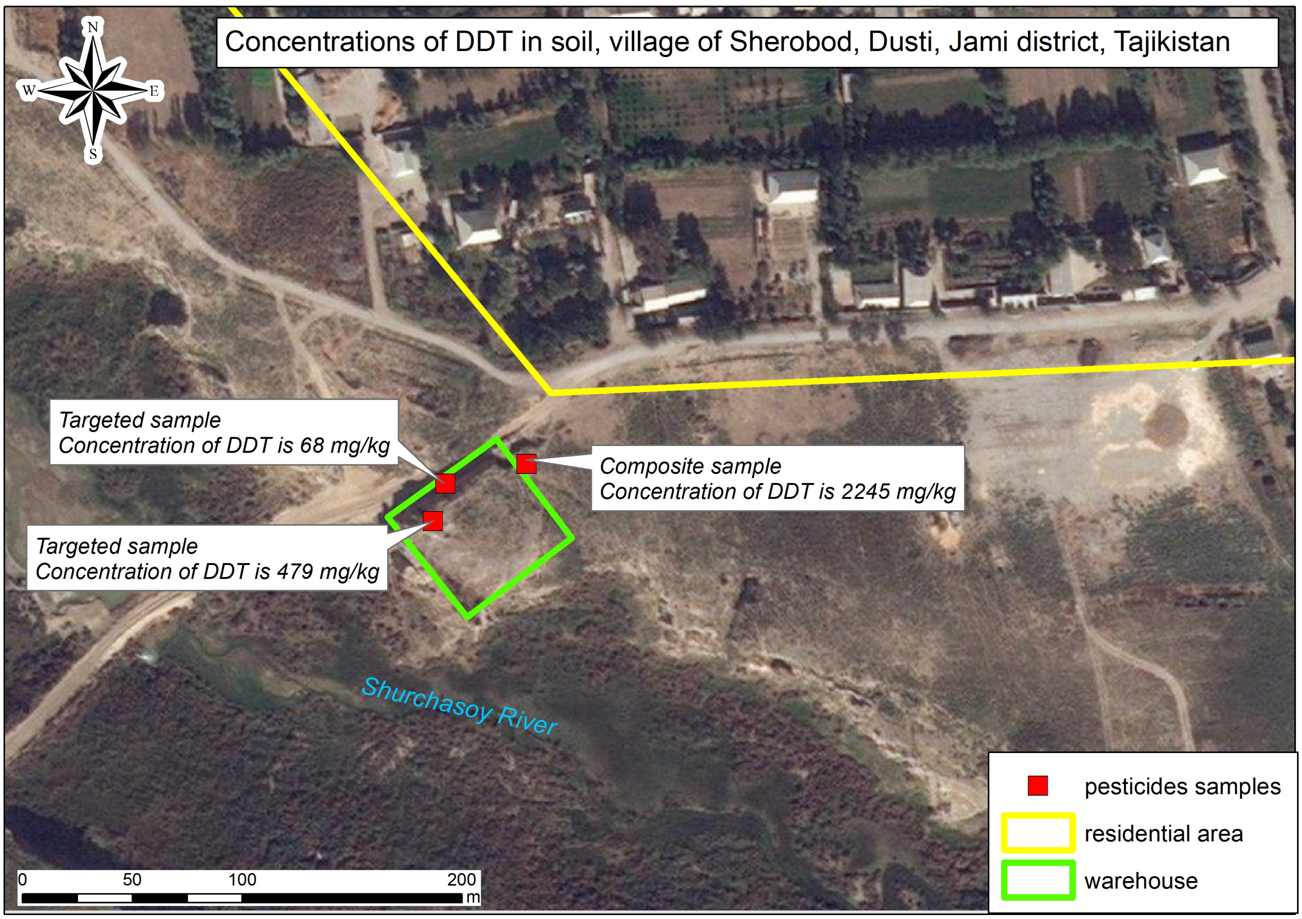

Figure 5. Concentrations of DDT in topsoil of pesticide burial in Sherobod

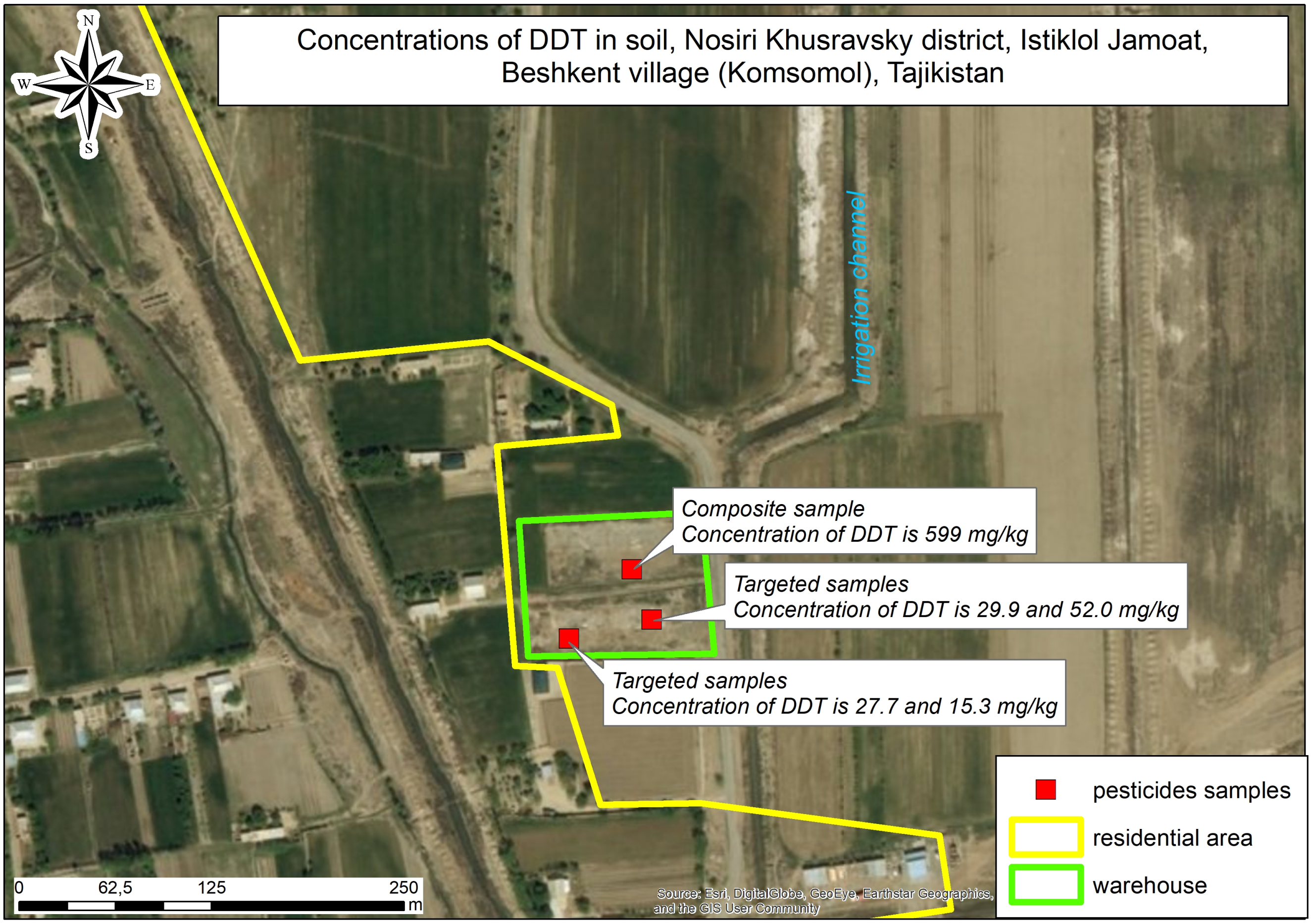

Figure 6. Concentrations of DDT in topsoil of former pesticide warehouse in Beshkent

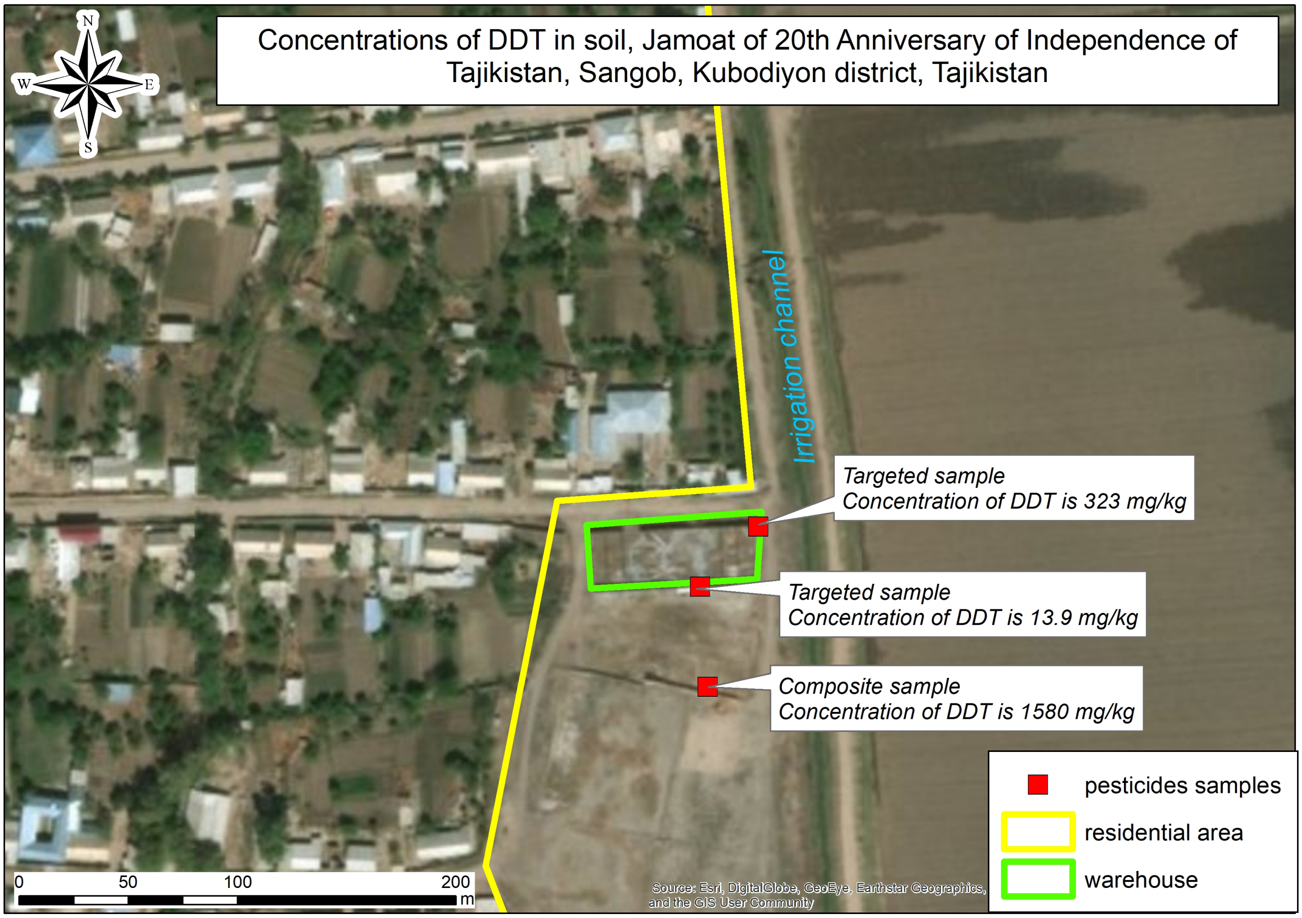

Figure 7. Concentrations of DDT in topsoil of former warehouse of pesticides in Sangob

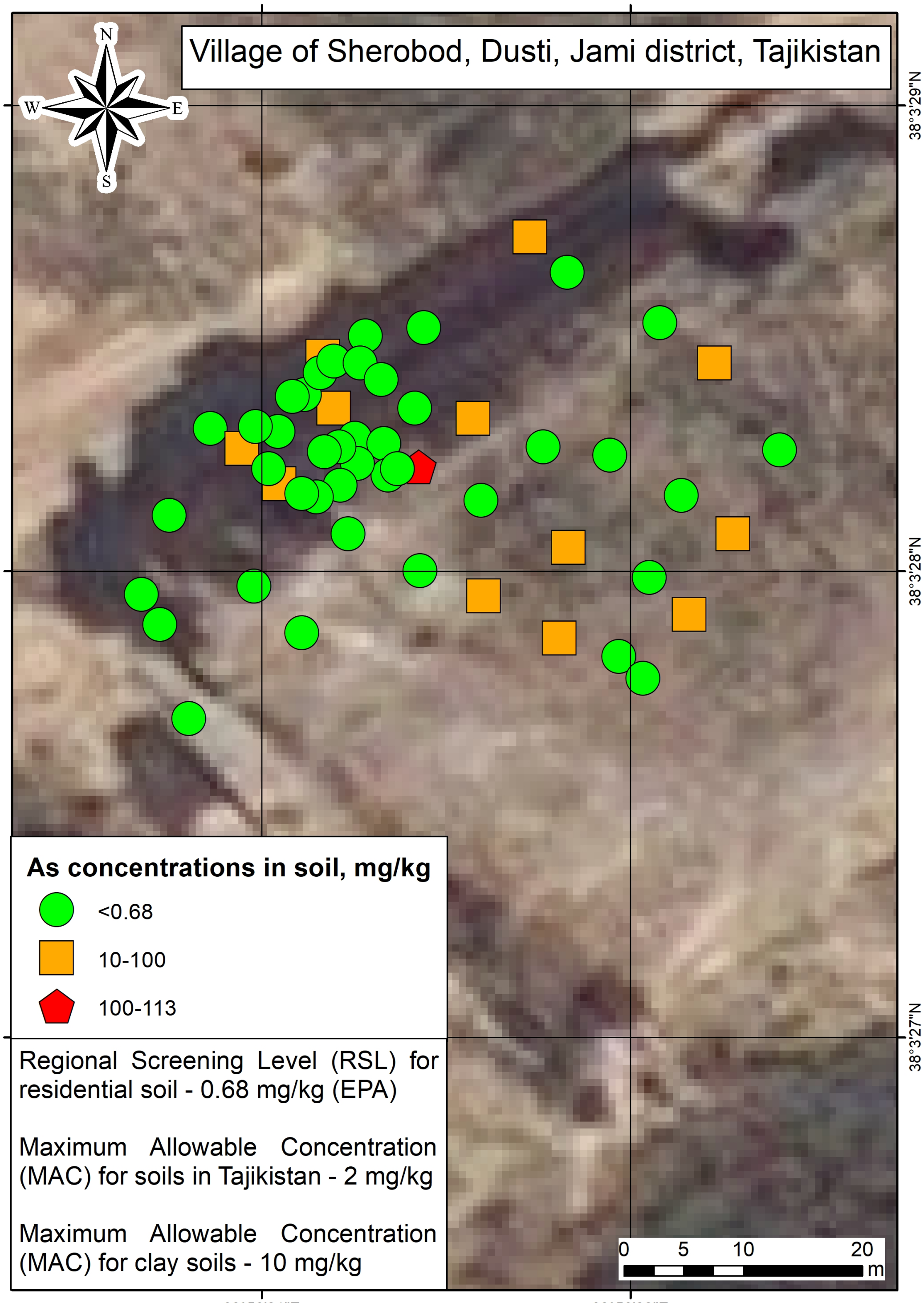

Figure 8. Concentrations of arsenic in topsoil of former pesticide warehouse in Sherobod

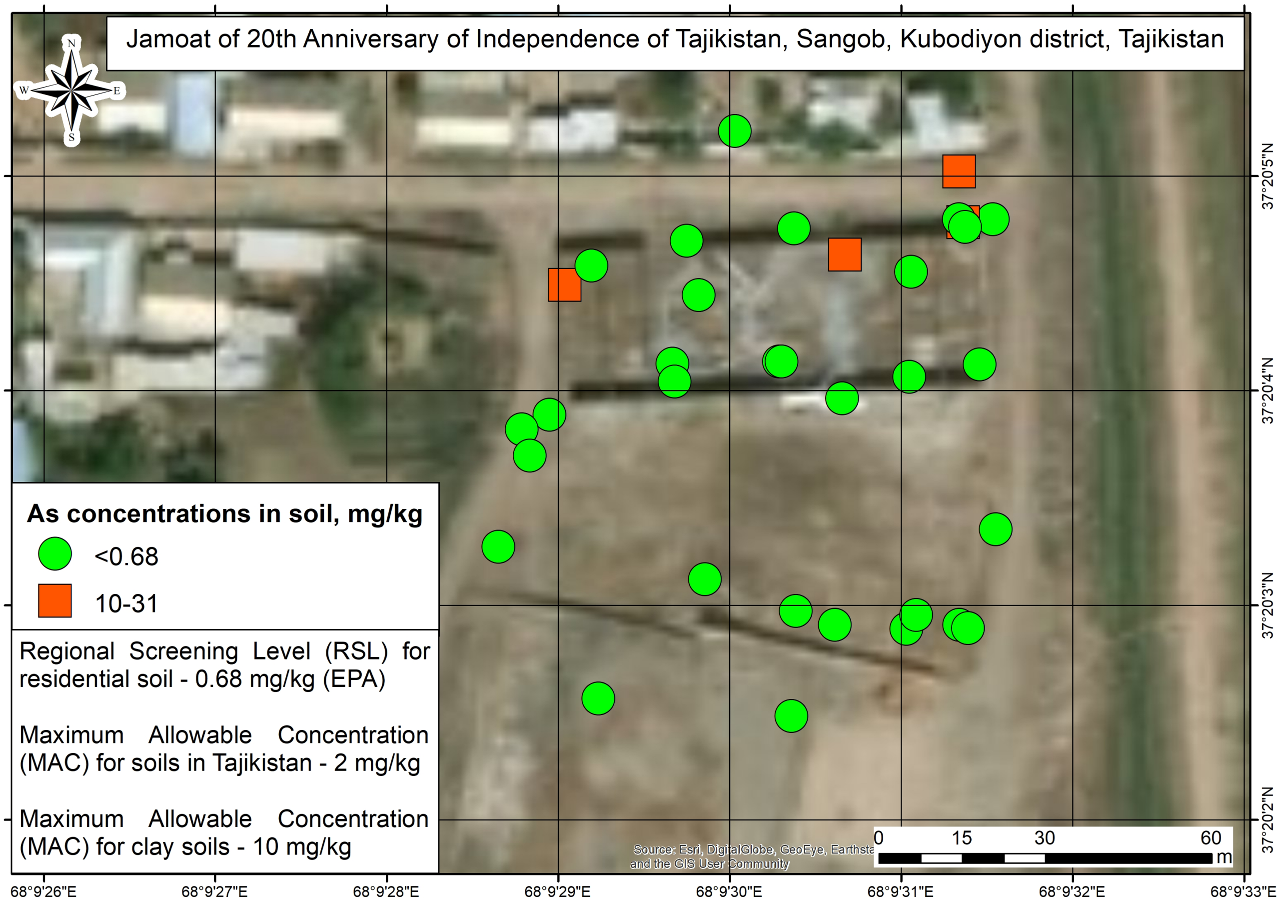

Figure 9. Concentrations of arsenic in topsoil of former warehouse of pesticides in Sangob

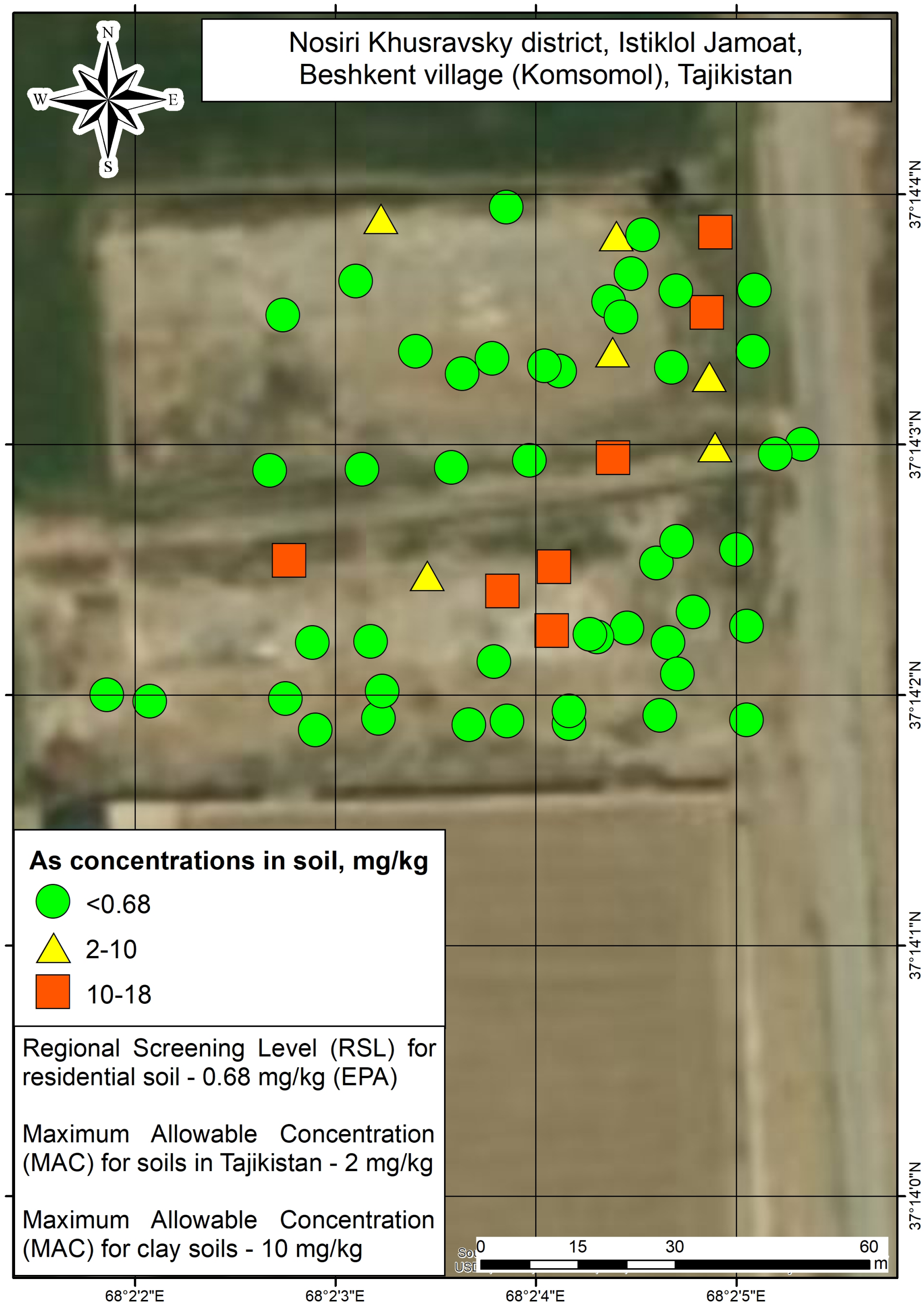

Figure 10. Concentrations of arsenic in topsoil of former pesticide warehouse in Beshkent

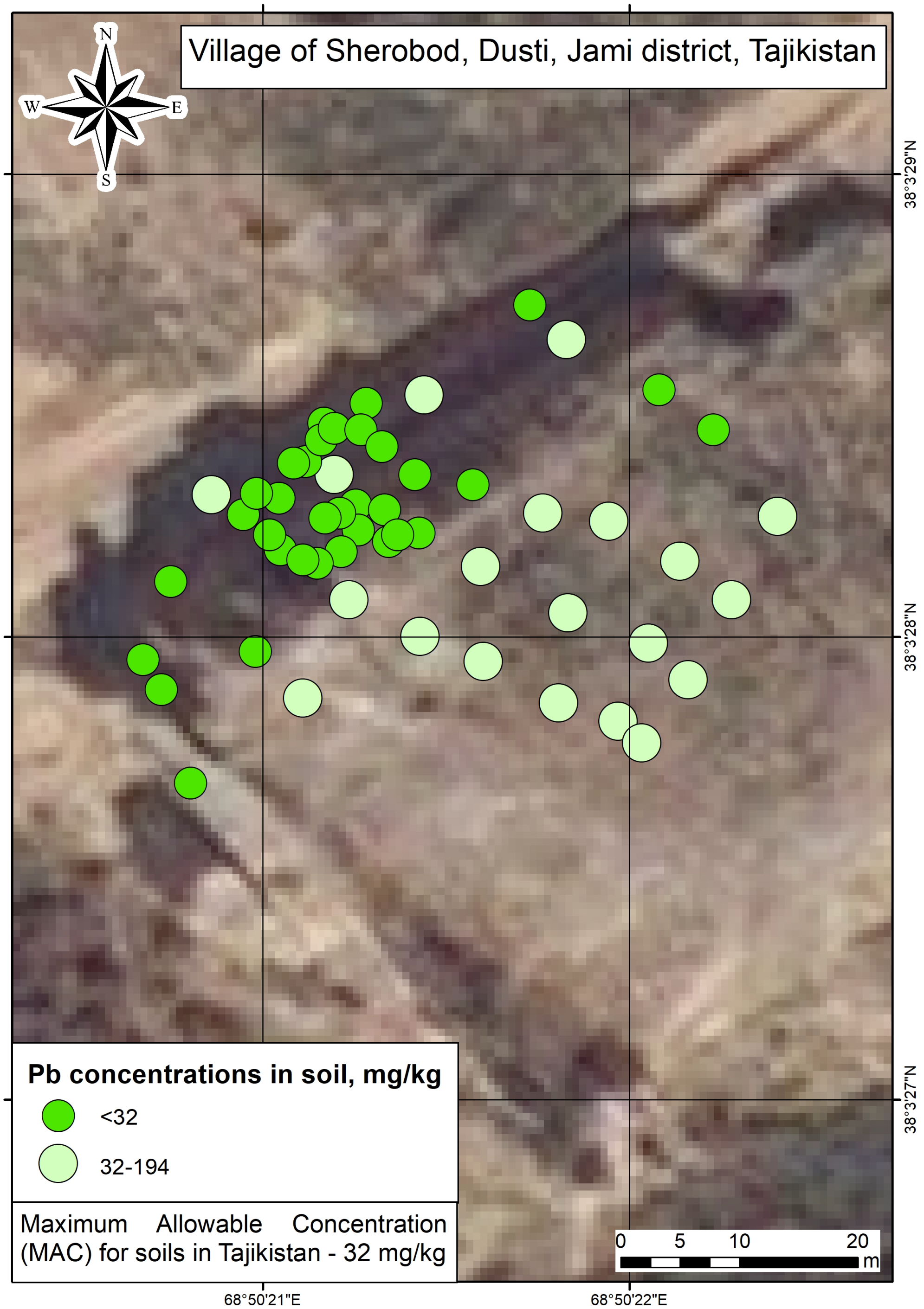

Figure 11. Concentrations of lead in topsoil of former pesticide warehouse in Sherobod

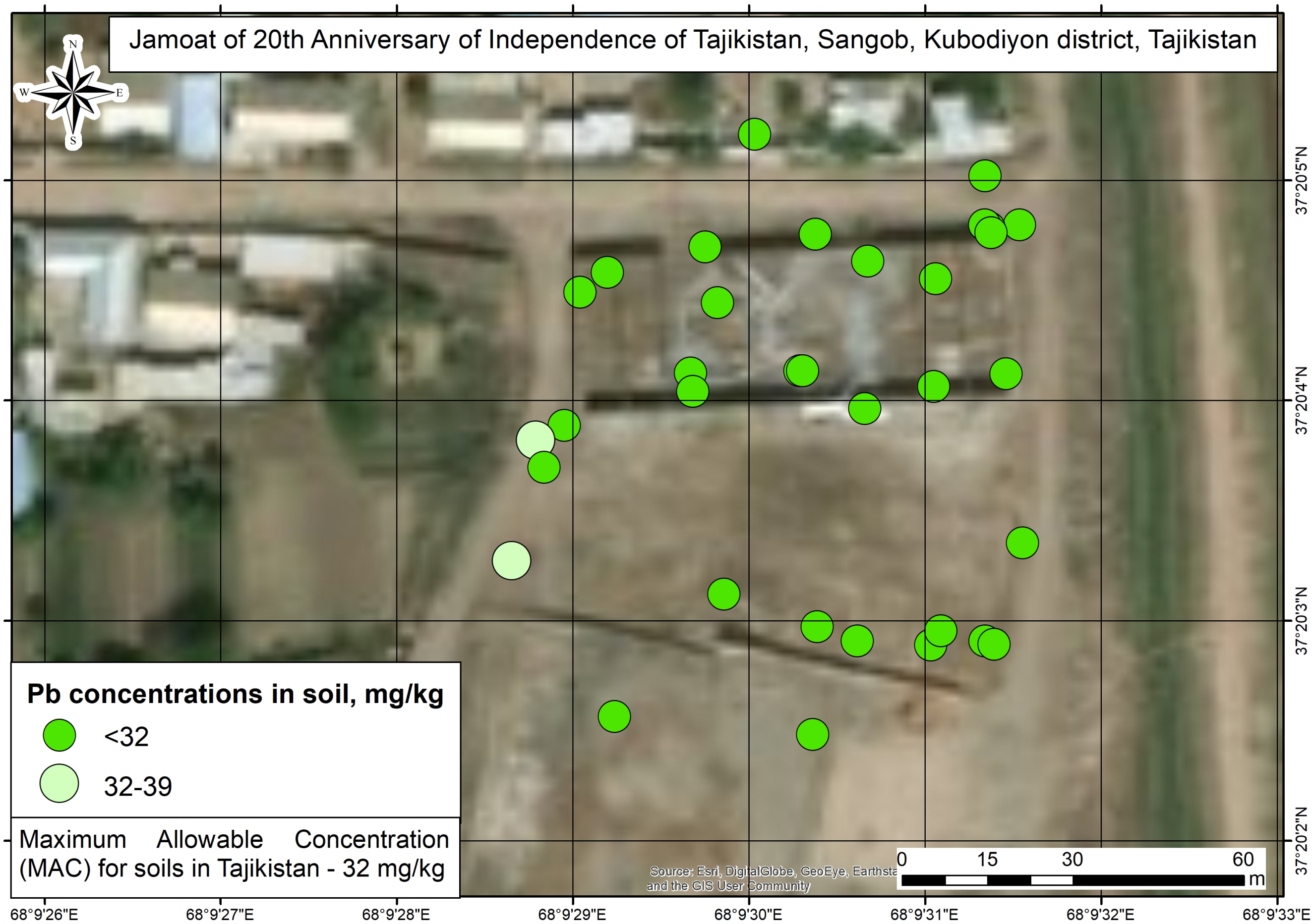

Figure 12. Concentrations of lead in topsoil of former warehouse of pesticides in Sangob

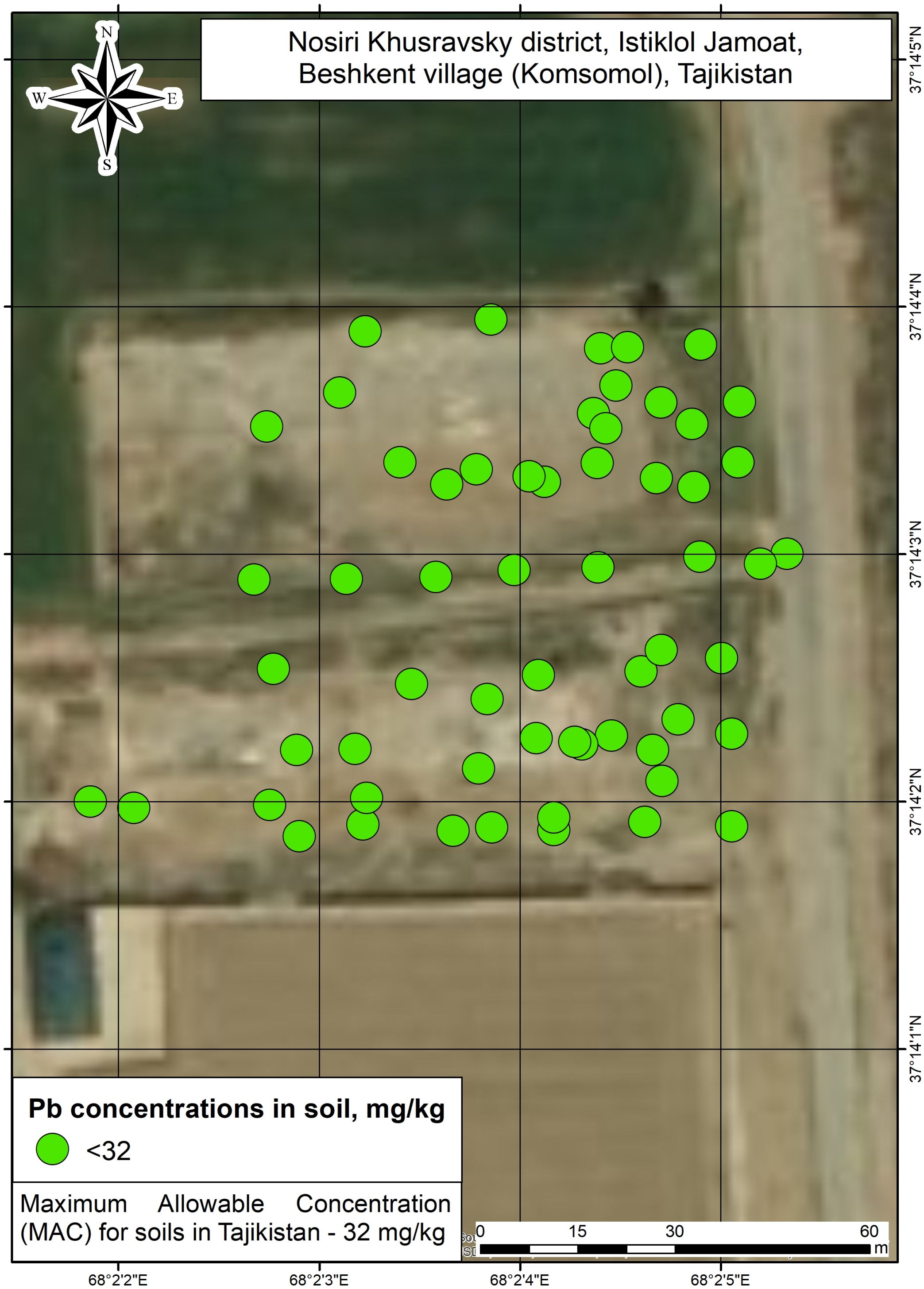

Figure 13. Concentrations of lead in topsoil of former pesticide warehouse in Beshkent

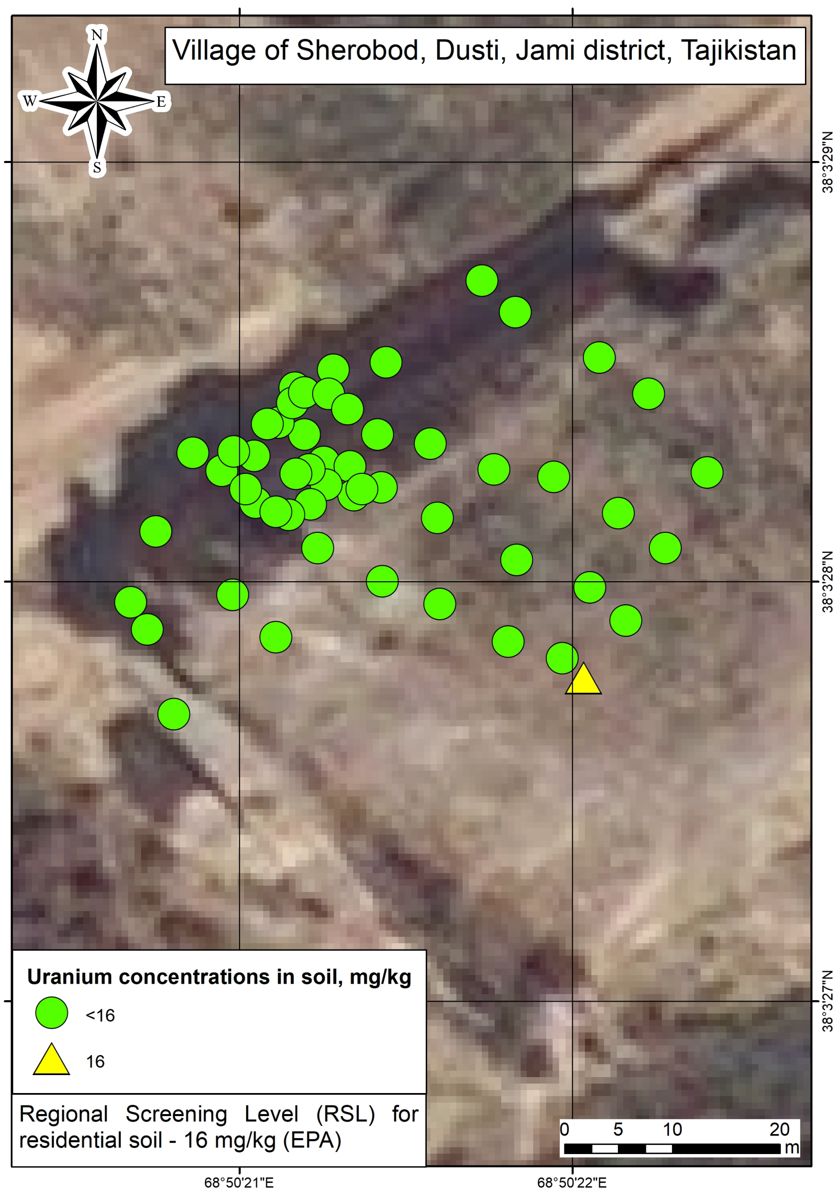

Figure 14. Concentrations of uranium in topsoil of former pesticide warehouse in Sherobod

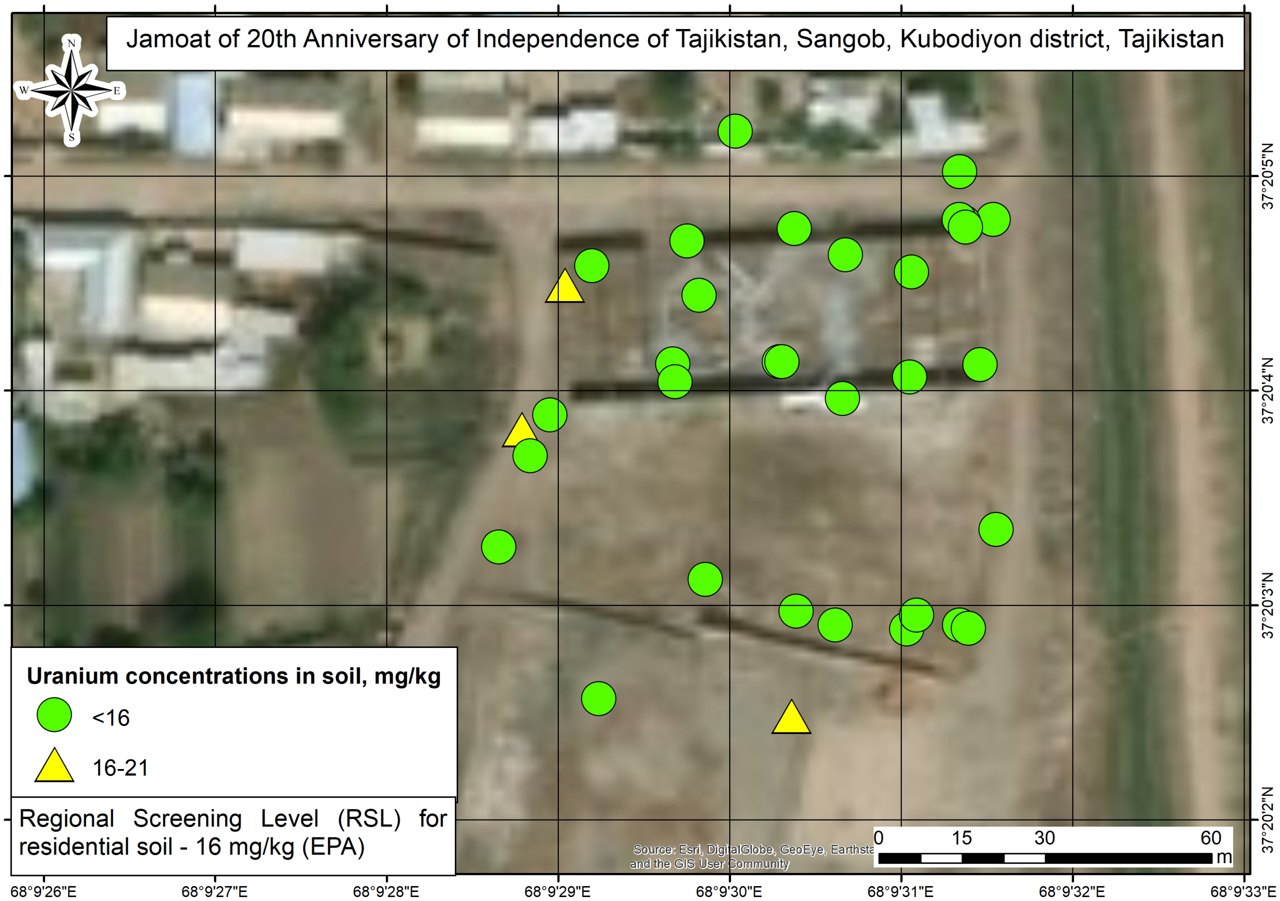

Figure 15. Concentrations of uranium in topsoil of former warehouse of pesticides in Sangob

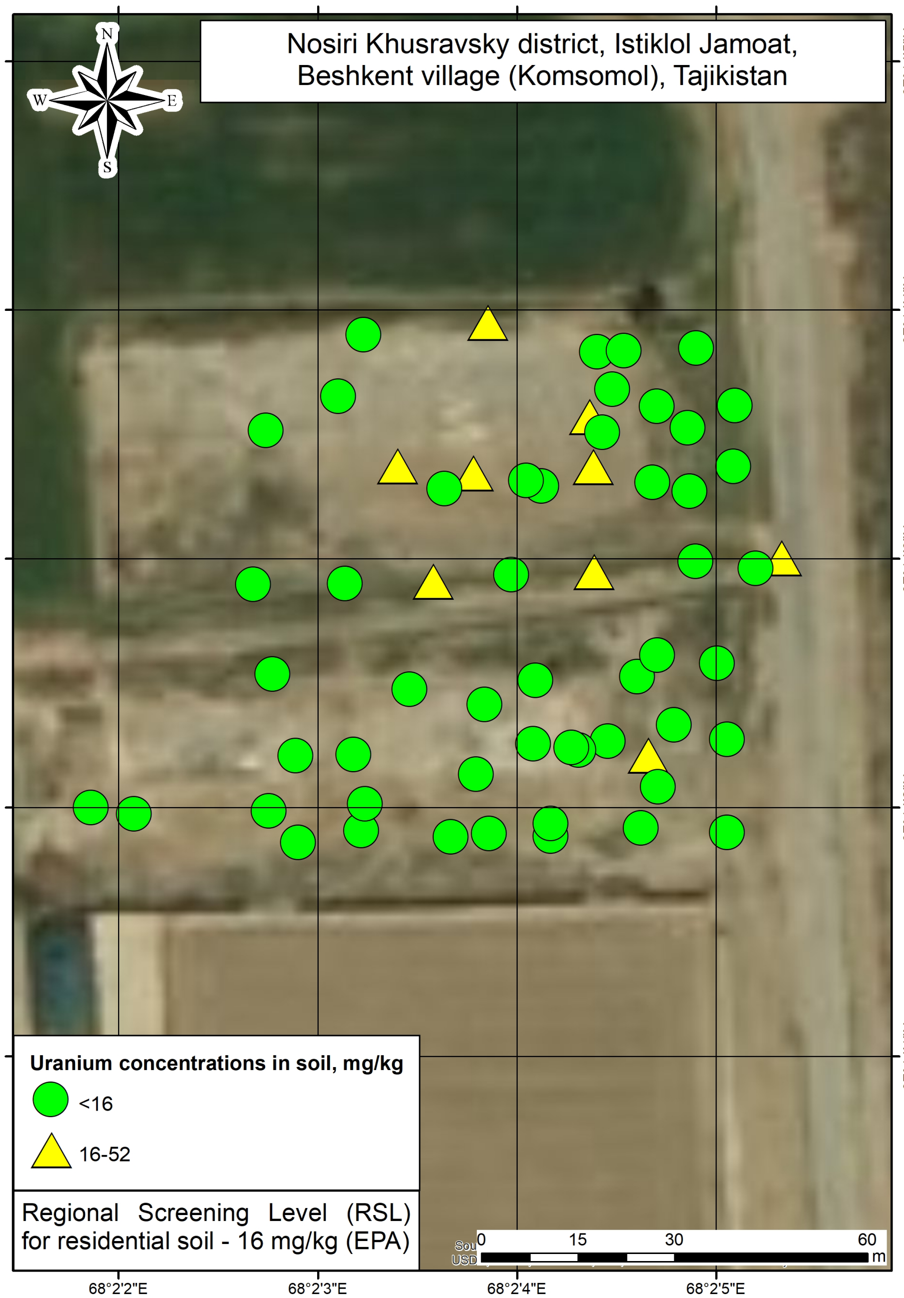

Figure 16. Concentrations of uranium in topsoil of former pesticide warehouse in Beshkent

CONCEPTUAL SITE MODEL

The project team analyzed the information about sources of contamination and the data obtained from sampling. The primary pollutants at the assessed sites were DDT and its impurities and/or metabolites. Two main sources of contamination were identified – buried pesticides and contaminated soil either due to contact with buried pesticides or through surface disposal.. In each site, there was one location of buried pesticides. The contaminated soil was on top or next to the pesticides and also spread on the remains of warehouses and nearby. This contamination in the form of vapors and dust spread through aeolian (wind) distribution. People and animals present in the contaminated area may be exposed to those vapors and dust. The exposure to vapors increases with high temperatures, especially in the summer.[23] The preliminary conceptual site model is presented below.

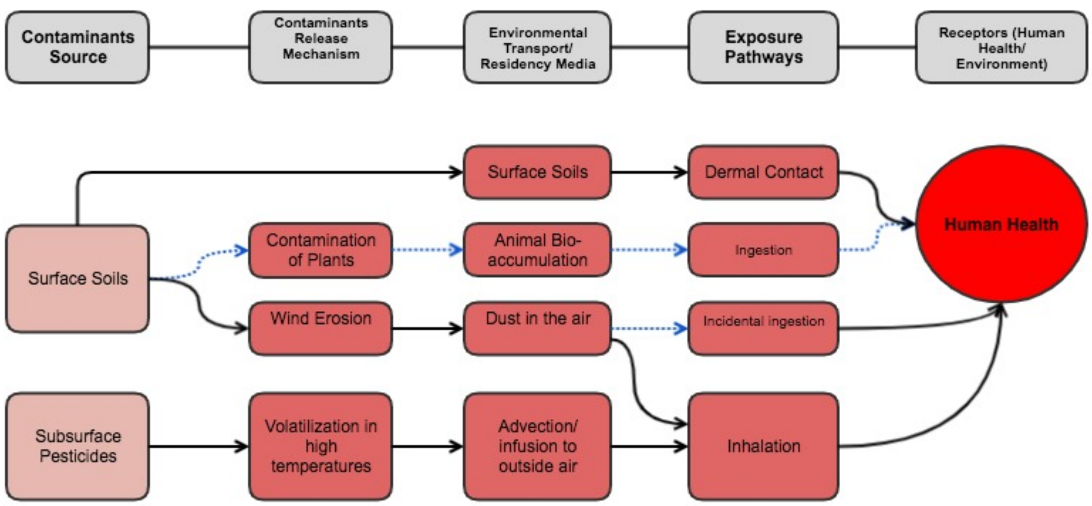

Figure 17. Preliminary conceptual site model.

HUMAN HEALTH RISKS

Burial of pesticides in Sherobod

There are about 800 people living near the site, 96 of them are children under 7 years of age. One of the most disturbing aspects of this particular site is that the local residents may dig up and sell the pesticides to the nearby farmers.

Table 6. Number of people in proximity of the contaminated area in Sherobod

	On site	Within 50 meters	Within 100 meters	Within 500 meters
Live	0	15	45	650
Work	0	0	0	30
Visit	0	10	20	30
Total across all categories:				800

Former storage of pesticides in Beshkent

There are two families residing on the site, which includes 9 people, 5 of whom are children. Besides this, 100 children pass the site daily on their way to school.

This site has seen increased development activity in recent years. The formerly rural area is turning into a small settlement. About 150 meters from the contaminated site there are about 120 family homes. The total approximate number of people in direct proximity to the site is more than 1000 people (Table 7).

Table 7. Number of people in proximity of the contaminated area in Beshkent

	On site	Within 50 meters	Within 100 meters	Within 500 meters
Live	9	20	60	420
Work	4	10	30	200
Visit	10	25	45	400
Total across all categories:				1233

Former storage of pesticides in Sangob

There are approximately 2000 people living in a small settlement near the site. There are about 30 people living in direct proximity to the site.

Table 8. Number of people in proximity of the contaminated area in Sangob

	On site	Within 50 meters	Within 100 meters	Within 500 meters
Live	0	20	100	300
Work	0	5	30	200
Visit	5	30	0	100
Total across all categories:				790

DATA GAPS

During performance of the DSA, it will be necessary to assess the volume of contaminated materials. More sampling of soil at different depths will be required to assess the extent of the contaminated area. In order to understand the possibility of migration of pesticides, it will also be necessary to analyze the structure of soil.

POSSIBLE RISK REDUCTION APPROACHES

This program for the identification and remediation of contaminated sites is aimed at identifying toxic sites that have existed for many years or are newly found. Sites are usually landfills at the site of the former pesticides warehouse or a site with contaminated soil, which can affect the health of the population.

There are various alternative approaches to reducing the risk of obsolete pesticides. Based on previous work experience in the country, it becomes obvious that the most acceptable option at the present time is through physical means, which involve directly removing or otherwise isolating contaminated soils, repackaging or isolation of pesticides, but the actual selection of risk reduction alternatives and recommendations will be presented after the Detailed Site Assessment is completed.

EXCAVATION

One of the options for restoring the burial sites of obsolete pesticides is the removal of contaminated soil. Burials are opened by an excavator; obsolete pesticides should be excavated with extreme caution. First of all, the topsoil over obsolete pesticides is removed and stacked on a platform of plywood board covered with a 200 micron thick plastic film. After excavation, contaminated soil should be transferred to special UN Big Bag bags (soft container) and transported to a temporary storage and/or disposal site. It is advised to dig up and transport heavily contaminated soil (pesticides content more than 50 mg / kg of soil) as well as the bottom and side walls of the burial to the storage waste facility. The resulting pit must be filled with clean soil and have a cap. To prevent wind erosion of the surface layer of the soil, it should be capped with a layer of grass. If obsolete pesticides are found, they are removed and, with extreme care, by slow movements of the excavator bucket, put into the UN Big Bags.

Possible environmental impact during excavation includes

The formation of dust that spreads around the excavation zone. Also, damage is possible to the excavator bucket of barrels of liquid pesticides that can end up in the pit and cause spills. This is especially dangerous in cases where the liquid obsolete pesticides can spill onto solid obsolete pesticides with the possibility of triggering an uncontrolled chemical reaction; or spillage onto fuel and engine oils.

Mitigation measures:

All staff are prohibited from working during strong winds and rain. During normal weather conditions, the installation of a wet screen is necessary, especially along vulnerable areas (water, agricultural land, residential areas) on the leeward side to partially capture dust on the wet surface of the screen. It is also advisable to extract barrels manually when possible (not by excavator). This technique is optimal for the prevention of spillage of fuel and oil onto the ground.

CAPPING

Another option for restoring the burial sites of obsolete pesticides is capping the burial site. In this case, obsolete pesticides remain buried in the ground (will not be removed and repackaged), and will remain at the burial site. Capping can be done in the form of a hill, made of clean soil, preferably clay, and shielded with plastic wrap. This prevents the accumulation and seepage of rain and melt water into the burial chamber. To prevent wind and / or water erosion, uncontaminated construction debris from the warehouse or gravel must be poured over the plastic film. After this grass is sowed it is necessary to establish a fence and organize additional measures to protect the soil from erosion, for example, planting trees.

The advantage of capturing is its low cost – Capping can be done by using previously available materials, and does not create risks related to repacking and difficulties in maintaining repackaged waste. But since buried obsolete pesticides remain in place, ongoing monitoring is required.

Capturing is an acceptable solution if: a large amount of pesticide is already buried; and the groundwater level is low, then the buried pesticides cannot contaminate groundwater. In such cases, for the foreseeable future, the site will not be used for other purposes. The site is also guaranteed supervision, service and management. Often this type of isolation is seen as a temporary solution, before the chemicals can be transferred to a more permanent storage facility.

However, it is important to keep in mind that capping is not applicable if: the volume of buried pesticides is small, the groundwater level is shallow and buried pesticides can pollute groundwater; or if in the near future the site will be used for other purposes. Also, if constant supervision, and other service and management are not guaranteed capping is not a good method to use

DEMOLITION OF POLLUTED WAREHOUSES

Demolition of the warehouses can only begin after a simple study on the subject of demolition and the provision of a finished work plan to the contractor. The work plan should include: location of the warehouse; the size of the building and its contaminated parts. Photographs illustrating the condition of the warehouse can be useful to the contractor in calculating costs and preparing for demolition.
Prerequisites for demolishing a building:

• the site of work should be divided into a clean zone, a contaminated zone and an intermediate zone (treatment zone);
• the aforementioned zoning must also be carried out to place materials at the place of work;
• workers will be provided with personal protective equipment, including hard hats and masks that fully protect the face;
• if workers are in the area of contact with pesticides, they must use appropriate personal protective equipment;
• measures must be taken to prevent the formation and spread of dust, for example, the use of water irrigation or film;
• before starting work, disconnect (if any) energy and water supply systems;
• Before starting demolition work, asbestos present inside and around the building should be collected in medium-sized plastic bags. Collected bags should be placed in large bags, which must be marked;
• in order to prevent additional costs of destruction, masonry contaminated with pesticides (bricks, concrete blocks), other materials (timber, concrete, asphalt, asbestos, etc.) and garbage, to the extent possible, should be separated from masonry unpolluted with pesticides, materials and garbage;
• Building demolition work can only begin after the removal and repackaging of obsolete pesticides and all materials containing asbestos;

• contaminated surface soil is removed in such a way as to minimize mixing of contaminated materials with clean soil;

• materials are removed from the site in stages, so as not to block the passage to the work area.

Uncontaminated construction materials are considered to be materials of market value and should be stored in designated areas until they are used in construction work.

RE-PACKING OF OSOLETE PESTICIDES

With respect to pesticide wastes, currently, in Tajikistan, there is no other alternative than their repackaging temporary storage and disposal. This is an obligation of Tajikistan as a Party to the Stockholm Convention on POPs.

Before repackaging obsolete pesticides, it is necessary to conduct a second inventory to establish new data on the quantity and quality of pesticide waste that will be repacked. A second inventory is also necessary to clarify the necessary financial resources for the implementation of this program.

The main condition of the repackaging program for obsolete pesticides is compliance with international standards developed by the Food and Agriculture Organization (FAO). During the repackaging process, the use of appropriate personal protective equipment approved by the UN is mandatory.

Repackaged obsolete pesticides should be transported to temporary storage facilities and stored until destruction in accordance with international and national requirements or disposed of in other ways, for example, by burial in localization cells (trenches) at the Vakhsh pesticide disposal site.

Procedure for the restoration of facilities contaminated with obsolete pesticides, repackaging of obsolete pesticides, possible environmental impacts and mitigation measures.

i) Excavation

Extraction of buried obsolete pesticides from pits and trenches is carried out by excavators. First of all, the topsoil over obsolete pesticides is removed and stacked on a platform of plywood board covered with a 200 micron thick plastic film.

Upon detection, obsolete pesticides are carefully removed and, with extreme caution (slow movements of the excavator bucket), poured into the UN Big Bag (soft container).

At the end of the work, the removed topsoil is placed in soft containers and moved to a place specially designated for these purposes.

Possible environmental impact during excavation: the formation of dust that spreads around the excavation zone; damage to the excavator bucket of barrels of liquid obsolete pesticides that may end up in the pit and cause them to spill onto solid obsolete pesticides with the possible launch of an uncontrolled chemical reaction; spillage of fuel and engine oils.

Mitigation measures: prohibition of work during strong winds and rain; installation of a wet screen along vulnerable areas (water, agricultural land, residential areas) on the leeward side to partially capture dust on the wet surface of the screen; manual extraction of barrels (if possible); prevention of spillage of fuel and oil to the ground.

ii) Repacking of solid obsolete pesticides

Solid pesticides can be detected at the facility piled in heaps or scattered across the floor of warehouses, in damaged bags, unmarked, and some in rusty barrels and buried. For safe transportation, the product should be repackaged. This is done manually: workers carefully, without opening, put the bag in soft containers that meet UN requirements. In the event that the obsolete powder pesticide is in a rusty metal barrel, the contents are poured into a soft container approved by the UN. Rusty barrels are crushed, and metal chips are poured into plastic barrels that meet UN requirements.

A significant part of the obsolete solid pesticides is buried in pits near warehouses. They are extracted using the excavation method and repackaged in soft containers that meet UN requirements.

Bags are marked so that later it is possible to determine their origin.

Possible effects of solid PM on the environment: dust generated when falling into bags; spill on the ground.

Measures to reduce exposure: the use of a special filling system will reduce dust; collection installation for filling on a plywood platform with fences on all sides, with a polyethylene coating; installation of a wet screen along sensitive areas (water body, agricultural land, residential areas) for partial dust collection due to a wet surface; if possible, repackaging obsolete pesticides inside the warehouse.

iii) Repacking liquid obsolete pesticides

Most obsolete liquid pesticides are stored in barrels that do not meet UN requirements. Despite the strength of these barrels, they are in any case not suitable for safe transportation. There are two alternatives for repackaging obsolete liquid pesticides:

One method consists in pumping liquids into new barrels that meet UN requirements, then absorbent is poured into an old empty barrel, and this barrel, together with the sorbent, is crushed and placed in plastic barrels that meet UN requirements;

The other method involves placing one barrel inside a larger barrel (280 liters) that meets UN requirements, then sealed.

Barrels are placed on pallets, marked and placed in a safe place. If there is a crusher for barrels, barrels can be destroyed during the same working period without the need for storage. If such a situation arises when the barrels cannot be crushed or crushed immediately (if there is no crusher), the barrels can be made unusable by drilling holes or cutting, and then they will be stored in a closed room. When stored until the crusher arrives, a record should be kept of the number of barrels in the daily report.

Possible environmental impacts during the repackaging of liquid obsolete pesticides may involve spillage onto the ground.

Impact mitigation measures: a barrel receiving obsolete pesticides is placed on a pallet, which, in turn, is placed on a plywood platform with fencing on all sides covered with plastic film; A sufficient amount of absorbent is scattered on the platform to immediately catch possible leaks of liquid obsolete pesticides.

iv) Associated waste - facility cleaning

All other waste associated with activities at the facility is removed by the team before leaving the facility. Among them: used personal protective equipment, packaging, used absorbent, dust / soil and contaminated water (if any) from floor cleaning, contaminated plastic film and plywood (if necessary) and similar items. When cleaning paved surfaces inside a building, the first cleaning is carried out with shovels and brooms, and as a rule, a vacuum cleaner is used to complete the cleaning, not a broom. This avoids the formation of dust in the room. Water use is minimized.

The purpose of these actions is to leave the object in its pure form after

completion of work.

v) Weighing obsolete pesticides

The procedure for weighing the waste of obsolete pesticides to be transported for temporary storage (if specified in the contract) is discussed between the parties involved (presumably by the Client, the turnkey company, and the work manager). As a rule, obsolete pesticides are weighed using suspended electronic scales.

vi) Loading - unloading obsolete pesticides

The loading and unloading of repackaged obsolete pesticides is carried out using a forklift, crane or truck with a folding platform. Loaders and cranes should have a carrying capacity of more than 2.5 tons.

Possible environmental impacts during loading and unloading: spillage or leakage of obsolete pesticides from falling bags.

Impact mitigation measures: loading area - the ground from the loading side is covered with plywood sheet covered with a 300 micron thick plastic film that can withstand the pressure of the forklift wheels; enough absorbent material is stored near the loading area so that it can be used immediately to remove a spill of liquid obsolete pesticides.

vii) Equipment cleaning

The equipment is cleaned within its area of use using rags, detergent, solvents or other appropriate methods (depending on the type of equipment). During washing, water is collected using an absorbent. The absorbent is collected, packaged and disposed of with waste.

viii) Shelter of an open pit after the end of a shift

To protect obsolete pesticides from contact with storm water, shelter at a work site is mandatory with any waterproof materials.

ix) Object security

It is important that the facility is guarded at night. This is organized by the project manager before starting work on the site.

STAKEHOLDER ENGAGEMENT

As part of PSA process the project team met with heads (hakims) of District Administrations and local administrations to discuss the findings and feasibility of risk reduction activities. The local administrators expressed support for continued assessment activities and promised to help the implementation of future risk reduction measures. The project team also interviewed local residents to find out about the contamination patterns and known health impacts.

In Sherobod in March 2019, a meeting was held with the chairman of the makhalla committee Yorov H.He himself, who as a resident of the village, knows about the burial. Yorov H. believes that the pesticide burial is harmless to the population because he is completely uninformed as to the harmful effects of pesticides on the human body.

In Beshkent in April 2019, the site investigators met with the chairman of the mahalla committee Murtazakulov Shodmon. As the chairman of the makhalinsky council, he did not directly participate in the distribution of the land, which occurred in the 1990s. The decision was made at the level of the Hukumat district. The chairman of the mahalla acknowledged that the problem of pesticides exists and people complained, especially the elderly. Because of this he made the decision to move the contaminated soil and place it near the road.

In Sangob in February 2019, a meeting was held with the head of the Jamoat “20 years of independence” Almurodov Tulkun. He said that local authorities are interested in cleaning the site and are aware of the danger that threatens their children.

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APPENDIX A: Photographs

Include annotated pictures capturing the layout of the site, as well as suspected contamination sources and exposure routes. A minimum of 10 photos should be included.

Photo 1. Site#1 Sherobod, general view of the site with cattle grazing in the area adjacent to the pesticide burial

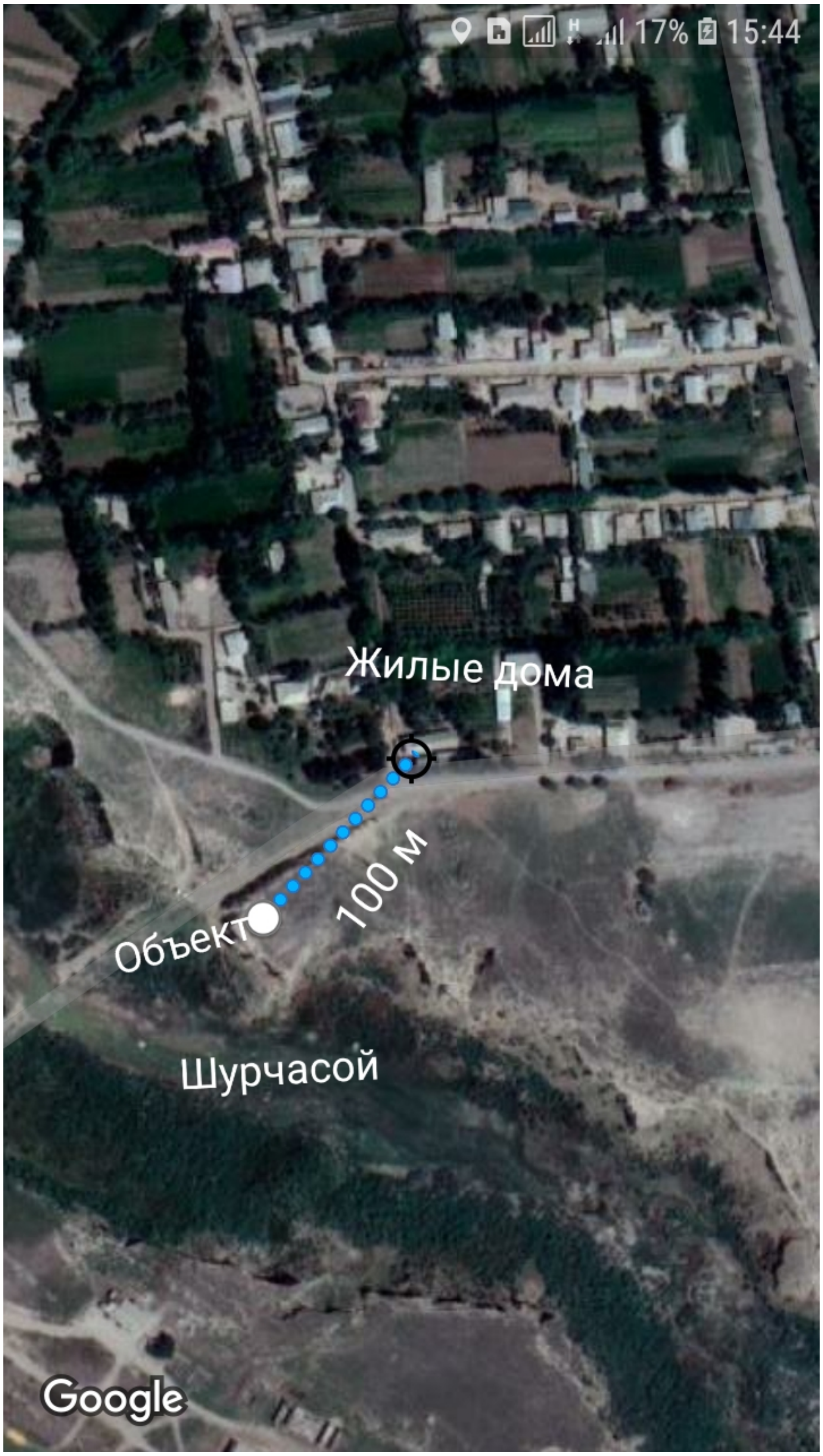

Photo 2. Site#1 Sherobod, the distance of the pesticide burial to the nearest house


Photo 3. Site#1 Sherobod, local children near the pesticide burial

Photo 4. Site#1 Sherobod, production of adobe bricks 50 meters from contaminated area

Photo 5. Site#1 Sherobod, production of adobe bricks 50 meters from contaminated area behind the bricks

Photo 6. Site#1 Sherobod, sampling for heavy metals with XRF, local vegetation, dry and dusty environment

Photo 7. Site#1 Sherobod, sampling for subsurface soil

Photo 8. Site#2 Beshkent, sampling in the western part of the site, near residential area


Photo 9. Site#2 Beshkent, view of the site from the eastern side, the remains of the pesticide storage, residential area to the west and north, and the rice field in the south


Photo 10. Site#2 Beshkent, cattle grazing on the site

Photo 11. Site#2 Beshkent, rice field to the south of the former storage foundation

Photo 12. Site#2 Beshkent, pile of soil and pesticides in the eastern part of the site

Photo 13. Site#2 Beshkent, sample location in the southern part of the site, near a wall, some pesticides were dumped here

Photo 14. Site#2 Beshkent, sample location with yellow dust

Photo 15. Site#3 Sangob, pile of soil with pesticides by the road

Photo 16. Site#3 Sangob, view of the site from the road (east), the remains of the pesticide storage behind vegetation

Photo 17. Site#3 Sangob, view of the site from the northern side, the remains of the pesticide storage behind vegetation

Photo 18. Site#3 Sangob, pile of soil with pesticides by the road, view from the northern side

Photo 19. Site#3 Sangob, pit on the eastern side of the foundation of the second (southern) former storage

Photo 20. Site#3 Sangob, sample location in the southwestern corner of the site, near stairs

Photo 21. Site#3 Sangob, sample location in the northeastern corner of the side between the pile and first foundation.

Photo 22. Site#3 Sangob, sample location in the area with yellow dust

APPENDIX B: Raw data

DDT Concentrations Data

Sample ID	Date	Latitude	Longtitude	Town	Soil type	Sample type	Depth cm	DDT, mg/kg	DDD, mg/kg	DDE, mg/kg
1	2019/02/04	37.23388	68.03398	Beshkent	soil	Target	10	27.7	9.5	0.74
2	2019/02/04	37.23420	68.03435	Beshkent	soil	Composite	10	599.0	190.0	29.6
3	2019/02/04	37.23397	68.03446	Beshkent	soil	Target	10	29.9	11.9	0.99
1	2019/03/09	38.05779	68.83923	Sherobod	soil	Target	10	479.0	190.0	4.93
2	2019/03/09	38.05791	68.83928	Sherobod	soil	Target	5	68.0	36.0	5.35
3	2019/03/09	38.05797	68.83961	Sherobod	soil	Composite	10	2245.0	819.0	6.17
1	2019/02/27	37.33465	68.15875	Sangoba	soil	Target	10	323.0	200.0	1.48
2	2019/02/27	37.33445	68.15851	Sangoba	soil	Target	10	13.9	9.5	0.37
3	2019/02/27	37.33412	68.15854	Sangoba	soil	Composite	10	1580.0	646.0	12.30

Heavy Metals Concentrations Data

Sample ID	Date	Longtitude	Latitude	Town	Soil type	Sample type	Depth, cm	Pb, mg/kg	As, mg/kg	Th, mg/kg	U, mg/kg
070	2019/09/25	68.83913	38.05786	Sherobod	clay	target	0	41			
071	2019/09/25	68.83915	38.05785	Sherobod	clay	target	0	16	17		
072	2019/09/25	68.83918	38.05783	Sherobod	clay	target	0	22	74		
073	2019/09/25	68.83923	38.0578	Sherobod	clay	target	0	45		14	
074	2019/09/25	68.83929	38.05778	Sherobod	clay	target	0	41		11	
075	2019/09/25	68.83933	38.05776	Sherobod	clay	target	0	35	16		
076	2019/09/25	68.83939	38.05774	Sherobod	clay	target	0	72	25		
077	2019/09/25	68.83944	38.05773	Sherobod	clay	target	0	121			
078	2019/09/25	68.83945	38.05771	Sherobod	clay	target	0	83			16
079	2019/09/25	68.83949	38.05775	Sherobod	clay	target	0	51	15	13	
080	2019/09/25	68.83946	38.05777	Sherobod	clay	target	0	71			
081	2019/09/25	68.83940	38.05779	Sherobod	clay	target	0	62	15	14	
082	2019/09/25	68.83933	38.05782	Sherobod	clay	target	0	34			
083	2019/09/25	68.83929	38.05784	Sherobod	clay	target	0	28	113	13	
084	2019/09/25	68.83922	38.05788	Sherobod	clay	target	0	67	27	21	
085	2019/09/25	68.83921	38.05791	Sherobod	clay	target	0	30	14	16	
086	2019/09/25	68.83929	38.05792	Sherobod	clay	target	0	194			
087	2019/09/25	68.83933	38.05787	Sherobod	clay	target	0	18	17	19	
088	2019/09/25	68.83938	38.05785	Sherobod	clay	target	0	47			
089	2019/09/25	68.83943	38.05785	Sherobod	clay	target	0	48		10	
090	2019/09/25	68.83948	38.05782	Sherobod	clay	target	0	38			
091	2019/09/25	68.83952	38.05780	Sherobod	clay	target	0	35	14		
092	2019/09/25	68.83956	38.05785	Sherobod	clay	target	0	36		13	
093	2019/09/25	68.83951	38.05790	Sherobod	clay	target	0	20	16		
094	2019/09/25	68.83947	38.05793	Sherobod	clay	target	0	20		11	
095	2019/09/25	68.83940	38.05796	Sherobod	clay	target	0	50		13	
096	2019/09/25	68.83937	38.05798	Sherobod	clay	target	0	26	17		
097	2019/09/25	68.83916	38.05777	Sherobod	clay	target	0	26		16	
098	2019/09/25	68.8392	38.05774	Sherobod	clay	target	0	44		13	

099	2019/09/25	68.83911	38.05769	Sherobod	clay	target	0	24		11	
100	2019/09/25	68.83909	38.05775	Sherobod	clay	target	0	30			
101	2019/09/25	68.83908	38.05776	Sherobod	clay	target	0	21		10	
102	2019/09/25	68.8391	38.05781	Sherobod	clay	target	0	30			
126	2019/09/26	68.03481	37.23417	Beshkent	soil	target	0	24		10	21
127	2019/09/26	68.03469	37.23416	Beshkent	soil	target	0	13	10		
128	2019/09/26	68.03455	37.23415	Beshkent	soil	target	0		13	11	25
129	2019/09/26	68.03444	37.23415	Beshkent	soil	target	0	12			
130	2019/09/26	68.03433	37.23414	Beshkent	soil	target	0	16			38
131	2019/09/26	68.0342	37.23414	Beshkent	soil	target	0			13	
132	2019/09/26	68.03408	37.23414	Beshkent	soil	target	0	12			
133	2019/09/26	68.0341	37.23404	Beshkent	soil	target	0		14	10	
134	2019/09/26	68.03414	37.23395	Beshkent	soil	target	0	16		11	
135	2019/09/26	68.03414	37.23385	Beshkent	soil	target	0	20		11	
136	2019/09/26	68.03423	37.23386	Beshkent	soil	target	0	13		11	
137	2019/09/26	68.03422	37.23395	Beshkent	soil	target	0	21		10	
138	2019/09/26	68.03429	37.23402	Beshkent	soil	target	0		10		
139	2019/09/26	68.0344	37.234	Beshkent	soil	target	0		11	17	
140	2019/09/26	68.03439	37.23393	Beshkent	soil	target	0	16			
141	2019/09/26	68.03441	37.23386	Beshkent	soil	target	0	22			
142	2019/09/26	68.03449	37.23386	Beshkent	soil	target	0	13			
143	2019/09/26	68.03447	37.23396	Beshkent	soil	target	0		11	14	
144	2019/09/26	68.03447	37.23403	Beshkent	soil	target	0		18		
145	2019/09/26	68.03457	37.23396	Beshkent	soil	target	0				
146	2019/09/26	68.03461	37.23404	Beshkent	soil	target	0	13			
147	2019/09/26	68.03463	37.23395	Beshkent	soil	target	0	24		17	35
148	2019/09/26	68.03462	37.23387	Beshkent	soil	target	0	18		9	
149	2019/09/26	68.03474	37.23386	Beshkent	soil	target	0	14		10	
150	2019/09/26	68.03474	37.23397	Beshkent	soil	target	0	13			
151	2019/09/26	68.03472	37.23405	Beshkent	soil	target	0	14		10	
152	2019/09/26	68.03469	37.23424	Beshkent	soil	target	0		9		
153	2019/09/26	68.03468	37.23431	Beshkent	soil	target	0	13	13		
154	2019/09/26	68.03469	37.2344	Beshkent	soil	target	0		11		
155	2019/09/26	68.03456	37.2344	Beshkent	soil	target	0		8		
156	2019/09/26	68.03455	37.23433	Beshkent	soil	target	0	14		9	24
159	2019/09/26	68.03455	37.23427	Beshkent	soil	target	0		9	11	31
160	2019/09/26	68.03448	37.23425	Beshkent	soil	target	0			9	
161	2019/09/26	68.03438	37.23426	Beshkent	soil	target	0	26		17	49
162	2019/09/26	68.03428	37.23427	Beshkent	soil	target	0	25			52
163	2019/09/26	68.0342	37.23435	Beshkent	soil	target	0	32		10	
164	2019/09/26	68.03423	37.23442	Beshkent	soil	target	0		10	9	
165	2019/09/26	68.0344	37.23443	Beshkent	soil	target	0	21			22
189	2019/09/26	68.10754	37.30335	Kumshok	soil	target	0	33			
190	2019/09/26	68.10744	37.30334	Kumshok	soil	target	0	18	12		
191	2019/09/26	68.10745	37.30333	Kumshok	soil	target	0	13			
192	2019/09/26	68.10752	37.30328	Kumshok	soil	target	0	28		11	
193	2019/09/26	68.10744	37.3033	Kumshok	soil	target	0	11	14	9	
194	2019/09/26	68.10749	37.30322	Kumshok	soil	target	0	29			
195	2019/09/26	68.10755	37.30306	Kumshok	soil	target	0	14	288	9	

196	2019/09/26	68.10755	37.30307	Kumshok	soil	target	0	19	35		
197	2019/09/26	68.10747	37.30307	Kumshok	soil	target	0	28	84		
198	2019/09/26	68.10753	37.30306	Kumshok	soil	target	0	29	23		
199	2019/09/26	68.10749	37.30306	Kumshok	soil	target	0	20			
200	2019/09/26	68.1076	37.30308	Kumshok	soil	target	0	22			
201	2019/09/26	68.10751	37.30366	Kumshok	soil	target	0	24	17	13	
202	2019/09/26	68.10748	37.30367	Kumshok	soil	target	0	30			
203	2019/09/26	68.10742	37.30371	Kumshok	soil	target	0	52			
204	2019/09/26	68.10742	37.30373	Kumshok	soil	target	0	30	20	12	
205	2019/09/26	68.10739	37.30377	Kumshok	soil	target	0	34	14		
206	2019/09/26	68.15876	37.33467	Sangoba	soil	target	0	31			
207	2019/09/26	68.15871	37.33473	Sangoba	soil	target	0	16	11		
208	2019/09/26	68.15871	37.33466	Sangoba	soil	target	0	17	12	12	
209	2019/09/26	68.15852	37.33462	Sangoba	soil	target	0	16	31	12	
210	2019/09/26	68.15826	37.33464	Sangoba	soil	target	0	21			12
211	2019/09/26	68.15807	37.33458	Sangoba	soil	target	0	21	11	16	21
212	2019/09/26	68.15804	37.33441	Sangoba	soil	target	0	27		16	
213	2019/09/26	68.15824	37.33448	Sangoba	soil	target	0	30			
214	2019/09/26	68.15852	37.33443	Sangoba	soil	target	0	27			
215	2019/09/26	68.15874	37.33448	Sangoba	soil	target	0	26		16	
216	2019/09/26	68.15871	37.33414	Sangoba	soil	target	0	32			
217	2019/09/26	68.15862	37.33414	Sangoba	soil	target	0	29			
218	2019/09/26	68.1585	37.33414	Sangoba	soil	target	0	10		9	11
219	2019/09/26	68.15843	37.33402	Sangoba	soil	target	0	21			16
220	2019/09/26	68.15812	37.33405	Sangoba	soil	target	0	25		13	
221	2019/09/26	68.15796	37.33424	Sangoba	soil	target	0	39			
222	2019/09/26	68.158	37.33439	Sangoba	soil	target	0	33		22	19

APPENDIX C: Regulatory correspondence

Include letters exchanged with regulators regarding the site.