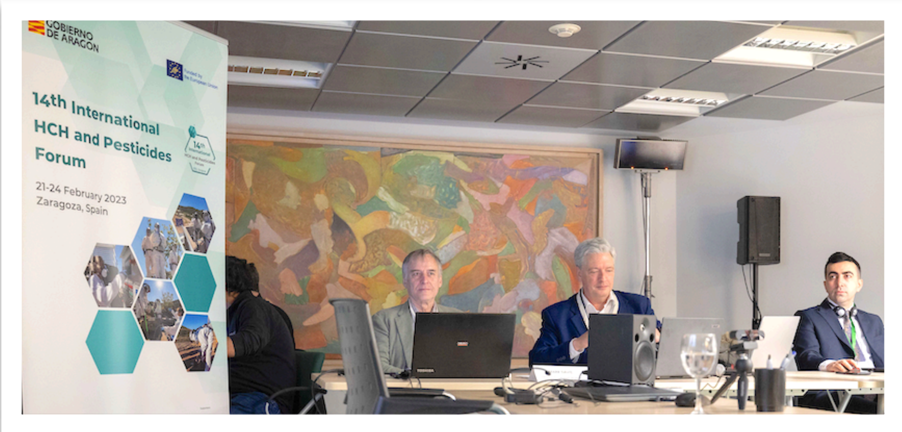
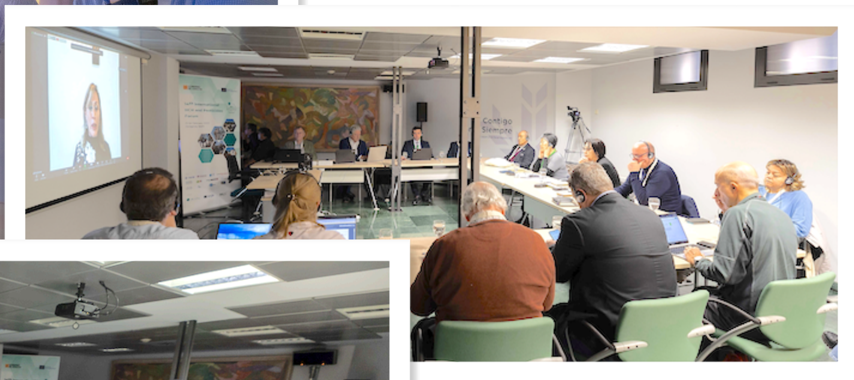
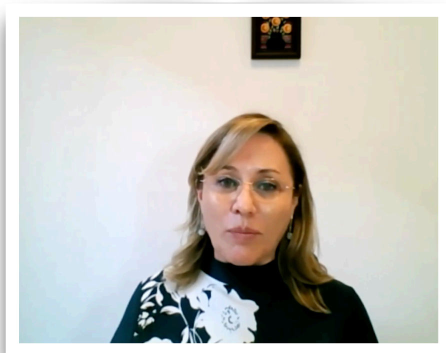
Block 10

LIFECYCLE MANAGEMENT OF PESTICIDES AND DISPOSAL IN CENTRAL ASIA COUNTRIES AND TÜRKIYE







ARE PESTICIDES OBSOLETE?

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Abstract

The mountains of HCH isomers and other obsolete pesticide stockpiles around the world that demand huge financial, technical and natural resources to manage safely, are one of several symptoms of a heavy reliance on pesticides for agricultural production and public health protection that has evolved over the past seven decades. While pesticide use globally has consistently increased over this period, estimates of crop losses to pests and diseases have not gone down and yields are plateauing. Understanding of the impacts of pesticides on health and the environment is evolving and shows significant damage in areas previously not well understood such as the soil microbiome and global suicides. Removing synthetic chemical pesticide has been shown to be feasible without additional crop losses where farmers are provided with viable alternatives. The trajectory for policy and regulation, private sector investment and agricultural advisory services should be towards the elimination of synthetic chemical pesticides and their replacement with sustainable alternatives that benefit human health, environmental protection, biodiversity and food safety.

INTRODUCING A DONOR PERSPECTIVE ON POPS MANAGEMENT WORK IN THE CENTRAL ASIA REGION

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GEF, TBC

Abstract

Reports from an EU-FAO study in 2015 show that a large part of the global obsolete pesticides stocks are situated in the former Soviet Union area including Central Asia. This is a result of the highly chemicalised agriculture practised in Soviet time with related mandatory pesticide applications and over-supply as part of the planning economy. In addition, the loss of management and control following the collapse of the Soviet Union has led to the destruction of numerous pesticide warehouses and illegal waste mining, resulting in enormous spread of pesticides in the near surroundings. While a lot of relevant work has been done over the last fifteen years by various UN agencies with support by the GEF and the EU, more support will still be needed in view of the still existing massive volumes of POPs and contaminated soil.

INVENTORIES AND ASSESSMENT OF REGIONAL DISPOSAL OPTIONS

Robinson, S.

FAO, Senior Technical Advisor

Abstract

An overview will be provided on ongoing activities to address the POPs legacy in Central Asia. Specifically, results of latest national inventories will be shared, which gives a better understanding of the types and volumes of wastes which need to be managed and what strategies need to be developed. Part of the wastes are currently being safeguarded at Azerbaijan's Jangi landfill. As exporting the wastes for disposal abroad is uneconomic and in most cases also not possible for legal reasons, the project also looks into possible national and subregional disposal options.

IN SITU IMPLEMENTATION OF TRIALS ON MICROBIOLOGICAL REMEDIATION OF POPS CONTAMINATED SOILS IN KYRGYZSTAN

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Summary

This study aimed to develop a bioaugmentation and bioremediation technology that can be used in situ at contaminated sites. For the bioaugmentation, three bacterial species were used: *Stenotrophomonas sp. (*Ps-B strain)*, Lysinobacillus fusiformis (*SA-4 strain) and *Esherihia cloacae* (SB-2 strain).

A former pesticide store in Chem–Korgon village (N 42049'23.9" and E 75031'49.8") in Kyrgyzstan was a suitable place for testing the efficacy of the bioremediation technology.

Three conditions were tested: application of fertile soil and bioproduct, application of fertile soil and no bioproduct (Control 1) and no fertile soil and no bioproduct (Control 2).

The most effective condition, in terms of pesticide degradation, was the application of fertile soil and the bioproduct. The degradation using this condition was 1.5 to 2 times higher than when only fertile soil was added (and no bioproduct) and five times higher than when no fertile soil and no bioproduct were added. Based on the results, we could state that the degradation of pesticides by microbes depends not only on the bacterial enzyme system but also on the conditions like temperature, pH of the soil, moisture contents and nutrients.

Further research will optimize the degradation conditions in a variety of soil types, and ex-situ conditions with high concentrations of pesticides, using the bacterial strains selected for this study.

Keywords

Obsolete pesticides, bioaugmentation, bioremediation in situ, biodegrading bacteria, degradation conditions

Introduction

Organochlorine pesticides are lipophilic and resist environmental degradation, so they tend to bioaccumulate in the tissues of living organisms and remain in the ecosystem trophic links.

On an annual basis, approximately three million people are exposed to the toxic effects of pesticides, and there are 300,000 deaths associated with pesticides [Adeyinka et al. 2020]; people involved in agriculture and rural populations are highly affected [Salazar-Flores et al.2020].

Once plentifully used but now banned, obsolete pesticides are stored in different parts of Kyrgyzstan due to their toxicity. Currently, 50 storage facilities for obsolete pesticides exist in Kyrgyzstan. They hold about 5,000 tons of these hazardous chemicals and pose a severe threat to the surrounding populations, livestock and environment.

Effective, economically viable and environmentally friendly methods must be used to remove residual pesticides and restore polluted ecosystems. One such method is bioremediation, an alternative to more expensive and toxic approaches, such as chemical and physical methods [Raffa and Chiampo 2021; Chawla et al.2013]. Bioremediation exploits the metabolism of certain groups of microorganisms that use pesticides as nutrients for their metabolic reactions and completely mineralise the pesticides or convert them into decomposition products. Enzymes such as hydrolases, peroxidases and oxygenases play the main role in the mechanisms utilised for pesticide biotransformation [Abatenh et al.2017; Vyas and Waoo 2020]. The overall objective of this study was to set up bacterial bioremediation field trials in soils heavily polluted by POPs. Following successful laboratory tests, these field trials shall 1) demonstrate the capability of the microorganisms to decompose chlorinated pesticides also in field conditions efficiently and 2) lead to a better understanding of the limitations (soil type, pollution type, climate, etc.) of this approach.

Methods and approaches

The former landfill for aircraft refuelling and aerial spraying of pesticides and their store located in the village of Chym-Korgon of the Kemin region was chosen to carry out the task of implementation trials on bioremediation of pesticides in the field.

A heavily degraded site that was previously used as a storage area was ploughed to a depth of 250–30 cm using a tractor to create suitable agrochemical conditions for bioaugmentation and activation of the local microflora. For chromatographic and microbiological analysis, samples were taken from different places in the ploughed area. The soil pH was carefully measured across the ploughed area over the course of the experimental period. The experimental field site was divided into the following four plots:

1. A plot with heavy contamination that had fertile soil and a bioproduct applied (14 × 15 m).
2. A control plot with fertile soil applied and no bioproduct applied (25 × 2 m).
3. A control plot with no fertile soil and bioproduct applied (10 × 10 m).

The introduced fertile soil was mixed with the contaminated soil and irrigated with water to activate the local microflora. To achieve an average moisture capacity in the contaminated soil, 18 tons of fertile soil per 40-m^2 plot was introduced.

To properly degrade the obsolete pesticides situated in their place of storage, we used a bioproduct comprised of three bacterial strains isolated from contaminated soils around the tailings of obsolete and banned pesticides in the Suzak region. The three bacterial strains were selected based on the results of in vitro tests and model soil experiments. Suspensions of the three selected bacteria (L. fusiformis, Stenotrophomonas sp. and E. cloacae) were prepared via submerged cultivation in a bioreactor (LAMBDA Laboratory Instruments, The Czech Republic, 7L).

Pesticide biodegradation (%) was calculated as the difference in the residual pesticide detected in soil from bioproduct-treated plots and in soil from untreated plots. The means and standard deviations of three replicates were computed using data analysis tools in Microsoft Excel 2013. Means were compared using least significant difference (LSD) tests with statistical significance set at $P \leq .05$ and MSTAT-C software (Mstat 6.1, Michigan State University, East Lansing, MI, USA).

Results

Pesticides detected in soil (10–35 cm deep) six months after the start of treatment

The soil chromatographic analyses conducted on soil samples collected three months after the start of treatment showed that most of the detected pesticides in the surface layers (10–12 cm) were 80–90% degraded in the experimental plots compared to the control plots. While a low level of degradation was observed in the lower layers, some pesticides (A-BHC, G-BHC and B-BHC) were not degraded. In contrast, others (B-DHC and heptachlor) underwent significant degradation. Thus, from the fourth month onward, we thoroughly mixed the soil to a depth of 35 cm twice a week. After six months, soil samples were taken from 20–35 cm depth. In Table 1, the results obtained after three bioproduct applications (end of May) are compared to the results obtained after nine bioproduct applications (beginning of December). During this period, almost all the detected pesticides were degraded up to 99.0 ± 0.05%, P≤0.5). Traces remained in the soil that could be removed by phytoremediation.

TABLE 1. COMPARISON OF PESTICIDE CONTENT IN THE SOIL BEFORE (MAY) AND SIX MONTHS AFTER (DECEMBER) THE INITIATION OF THE APPLICATION OF THE BIOREMEDIATION TECHNOLOGY

No	Pesticide	Concentration in control soil (fertile soil + no bioproduct) (mg/kg ± SD)		Concentration in experimental soil (fertile soil + bioproduct) (mg/kg ± SD)	
		May, 2021	December, 2021	May, 2021	December, 2021
1	A-BHC	0.231±0.05	0.019±0.03	0.270±0.03	0.047±0.02
2	B-BHC	0.225±0.02	0.014±0.01	0.380±0.03	0.043±0.04

No	Pesticide	Concentration in control soil (fertile soil + no bioproduct) (mg/kg ± SD)		Concentration in experimental soil (fertile soil + bioproduct) (mg/kg ± SD)	
		May, 2021	December, 2021	May, 2021	December, 2021
3	G-BHC	0.240±0.02	0.007±0.02	0.170±0.03	0.015±0.05
4	D-BHC	0.926±0.03	0.008±0.02	0.686±0.04	0.046±0.03
5	Heptachlor	0.476±0.05	0.016±0.03	0.550±0.05	0.005±0.05
6	Aldrine	0.903±0.02	0.146±0.02	1.418±0.01	0.044±0.02
7	Heptachlor-epox	0,878±0.03	0,779±0.01	2.544±0.02	0.039±0.02
8	G-Chlordane	1.439±0.03	0.259±0.02	2.625±0.03	0.011±0.03
9	Endosul-1-A-Chlordane	0.916±0.05	0.365±0.03	2.048±0.03	0.009±0.03
10	4.4 DDE	1.062±0.04	0.260±0.05	2.060±0.02	0.138±0.02
11	Dieldrine	1.350±0.04	0.216±0.01	4.347±0.04	0.035±0.03
12	Endrine	1.022±0.05	0.452±0.02	2.223±0.05	0.105±0.05
13	Endosulfane-2	2.615±0.03	1.584±0.02	2.088±0.02	0.079±0.03
14	4.4 DDD	3.662±0.02	0.028±0.04	9.706±0.3	0.060±0.03
15	Endrine-Aldehid	1.128±0.04	0.774±0.03	1.876±0.03	0.273±0.04
16	Endosulfan-sulfat	2.174±0.01	1.974±0.03	5.079±0.02	0.064±0.03
17	4.4 DDT	1.734±0.02	0.101±0.02	3.298±0.02	0.248±0.02
18	Endrine-ketone	1.314±0.01	0.130±0.03	2.057±0.02	0.002±0.03
19	Metoxichlor	0.733±0.03	0.307±0.02	0.974±0.03	0.006±0.03

Conclusion

Our findings demonstrate that the bioproduct developed from the above bacterial species is a highly effective pesticide decomposition tool. In this study, up to 99.0± 0.05% (P≤0.05) of pesticides were degraded within six months of the initiation of the bioremediation process.The efficiency of the degradation process depends upon optimum atmospheric conditions, that is, temperature, pH of the soil, and moisture contents.

References

1. Adeyinka A, Muco E, Pierre L (2020) Organophosphates. [Updated 2020 Aug 16]. StatPearls [Internet]. Treasure Island (FL): StatPearls. Publishing Available from https://www.ncbi.nlm.nih.gov/books/NBK499860/

2. Salazar-Flores J, Pacheco-Moisés F.P., Ortiz G.G., Torres-Jasso J.H., Romero-Rentería O., Briones-Torres A.L, Torres-Sánchez E.D. (2020) Occupational exposure to organophosphorus and carbamates in farmers in La Cienega, Jalisco, Mexico: Oxidative stress and membrane fluidity markers. Journal of Occupational Medicine and Toxicology 15(1): 111.

3. Raffa C.M., Chiampo F. (2021) Bioremediation of Agricultural Soils Polluted with Pesticides: A Review. Bioengineering 8: 92. https://doi.org/10.3390/bioengineering8070092.

PHYTOREMEDIATION OF POPS-CONTAMINATED SOILS: SOLUTIONS AND DEVELOPMENT POTENTIAL IN KAZAKHSTAN

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Abstract

Organochlorine pesticides, especially those belonging to persistent organic pollutants, are causing rising concern. Environmental monitoring investigations identify polluted sites regularly, limiting their utilisation. Kazakhstan is facing increasing problems of soil pollution caused by unutilised obsolete pesticides. In 2012, 1500 tons of obsolete pesticides and their mixtures across the country along with 602 pesticide warehouses were recorded whereas 64 out of 602 are located in the Almaty region. For recovering soils damaged by the aforementioned substances, phytoremediation has great potential. Remediation of such sites is a crucial step in preventing the damaging effects of contaminants on the environment and human health. Since existing technologies are exceedingly energy-intensive and need a significant financial commitment, phytoremediation is a real alternative interacting harmoniously with the surrounding environment. This technology relies on plants to allocate, degrade, immobilize, and uptake toxic compounds from soil. However, in spite of the obvious benefits, phytoremediation has significant limits such as a lengthy remediation duration, climatic differences, and the use of non-native species that might lead to a biodiversity violation.

The current study aimed to assess the phytoremediation potential of *Miscanthus sp*. concerning organochlorine pesticides, as intensive agricultural practices, notably disposal and former storage facilities of obsolete pesticides in the 1960s, have been documented to damage the Kazakhstan environment. The soil was collected at the former pesticide storage facility in Kyzylkairat, Almaty region, Kazakhstan. The analysis showed the presence of 24 OCPs in the research soil and concentrations of chlorobenzilate, DDT, 2.4-DDD, 4.4-DDD, endrin, and heptachlor significantly exceeded (up to 100 times) the permitted levels for those substances established by Kazakh legislation. Despite the high concentrations of OCPs in the soil and significant differences in the agrochemical parameters of the polluted and controlled soils, *Miscanthus* sp. showed minimal changes in growth in the polluted soil (95% of the control), the dry weight of aboveground biomass decreased by 23%. The results of chemical analysis illustrated that only ten (α-HCH, β-HCH, γ-HCH, 2.4-DDD, 4.4-DDE, 4.4-DDD, 4.4-DDT, aldrin, dieldrin, and endrin) out of 24 OCPs detected in the historically contaminated soil were presented in *Miscanthus* sp. tissues. Optimising the growth conditions of the second-generation crops *Miscanthus* sp. with activated carbon showed that cultivating plants on pesticide-contaminated soils produced comparatively clean biomass for conversion into bioproducts.

Thus, the second-generation crop *Miscanthus* sp. as a novel phyto plant can be used for remediation of the pesticide-contaminated soil. Plants acquired a physiological resistance mechanism during adaptation to POP-pesticides, i.e., the accumulation and migration of POP-pesticides in the "soil-root-aboveground biomass" system via phytostabilization and phytoextraction processes.

AWARENESS RAISING WORK IN MINI-LANDFILL AREAS IN TAJIKISTAN, PLANNING FOR REMEDIATION OF VILLAGE #1 MINI-LANDFILL

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Abstract

Tajikistan has to deal with a legacy of about 200 so-called mini-landfills. Many of these highly contaminated sites are today located within populated areas. A series of awareness raising seminars was organised in 2022 in affected communities, showing the need for further such meetings. In parallel, detailed site assessment and planning for the remediation in 2023 of one of the high-risk mini-landfills in Village #1 has been completed.

EMPTY CONTAINER MANAGEMENT

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Abstract

Pesticide containers are mostly made of high-quality plastic. Thus, there is a risk that, once they are empty, they are not disposed of properly but reused for various purposes including storage of food. Many countries have, therefore, introduced Container Management Systems (CMS). An overview on the efforts to introduce CMS in the Central Asia region will be provided.

HIGHLY HAZARDOUS PESTICIDE (HHP) ASSESSMENT, REDUCTION OF PESTICIDE USE

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Abstract

So called Highly Hazardous Pesticides (HHP) pose above-average risks to farmers and food safety. An assessment of the pesticide registration lists of the project countries showed that all of them still have a number of HHPs permitted for use. To allow phase-out of HHPs, the project is promoting various types of agriculture relying on reduced use of pesticides. E.g. in apple production in Türkiye, pesticide use against codling moth could be reduced on average by 70% by the use of pheromone traps. These efforts are key to reaching the global goal of reducing by half both excess nutrients and the overall risk posed by pesticides and highly hazardous chemicals pesticide application (Biodiversity Convention, December 2022).

SUGGEST INITIATIVE ON RESOLVING POPS LEGACY IN CENTRAL ASIA

Robinson, S.

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Wrap-up

A long-term challenge in POPs management in Central Asia is treatment of the large volumes of contaminated soil. However, without safe soils no safe life. Creation of a working group shall be facilitated, bringing together decision-makers able to promote solutions, scientists with experience in soil remediation and improvement of soil fertility, and industry experts with the experience in scaling up treatment technologies to industrial scale needed for treating large areas. The working group shall help ensure that essential experience is acquired and shared within the countries of the region and that the importance of soil remediation and improvement is adequately reflected on political agendas.

Submitted paper

THE PROBLEMS OF PESTICIDES IN SOUTHERN KYRGYZSTAN AND ASSESSMENT OF THE POSSIBILITIES OF USING VEGETABLES FOR SOIL REMEDIATION

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FIGURE 1. OVERVIEW OF THE AK-CHABYR PESTICIDE BURIAL SITE

The Ak-Chabyr pesticide burial site is located on the territory of Jalal-Abad region. 1876.38 tonnes of OCPs including 1033.4 tonnes of POPs were buried at the site.

Studies conducted in the vicinity of the Ak-Chabyr pesticide burial site showed the following concentration levels of OCPs in soil: HCH (267.8mg/kg; 21.14mg/kg), DDT (767.7mg/kg; 17.07mg/kg,), DDD (147.1mg/kg; 13.4mg/kg), DDE (60.09mg/kg; 9.4mg/kg) were detected in soil samples taken from the areas located at a distance of 1 and 3 km from the pesticide burial site, respectively. HCH concentration level in wheat was 2.8 mg/kg, DDT–2.7, DDD–1.1 and DDE–3.09. Even insects were found dead in this area. The following pesticides were isolated from beetles: HCH-α–1.84 mg/kg, HCH-γ–22.85 mg/kg, DDE–7.11 mg/kg, DDD–3.5 mg/kg, DDT–8.95 mg/kg. Aldrin, dieldrin were not detected.

FIGURE 2. DEAD BEETLES

FIGURE 3. PARTS OF DEAD ANIMALS

FIGURE 4. A DEAD LIZARD

FIGURE 5. A DEAD SNAKE

In 2010, concentration levels of OCPs measured in the meat of a dead sheep were as follows: HCH-α - 0.013 ±0.001 mg/kg, HCH-γ - 0.005 ±0.001 mg/kg, HCH-β - <0.001 mg/kg; DDT - 0.018 ±0.002 mg/kg; DDD - 0.0036 ±0.0003 mg/kg, DDE - 0.022 ±0.0002 mg/kg, total - 0.0626 mg/kg. Concentration levels of OCPs in the meat of dead animals were as follows: HCH -2.0; DDT-3.0, DDE-0.5 mg/kg.

FIGURE 6. MEETING WITH A FAMILY LIVING NEAR THE PESTICIDE BURIAL SITE

Breast milk of 6 women were examined, all samples showed the presence of HCH, DDE with concentration levels ranged from 0.03 to 2 mg/l. The incidence rate of breast cancer in this area was 20.6 per 100 thousand female population versus 4.8 in pesticide-free zones.

HCH-α (0.003) and DDE (0.03–2 mg/l) were found in breast milk of 6 women under examination. The incidence of hepatitis was 5-6 times more frequently reported in this area.

FIGURE 7. SHEEP GRAZING NEAR THE PESTICIDE BURIAL SITE

FIGURE 8. CATTLE GRAZING IN THE VICINITY OF THE AK-CHABYR PESTICIDE BURIAL SITE

FIGURE 9. A WARM UNDERGROUND SPRING LOCATED IN 15 KM DOWNSTREAM THE AK-CHABYR PESTICIDE BURIAL SITE

Milk samples collected from the sheep grazing on the territory located in the vicinity of the pesticide burial site showed the presence of HCH-α, DDE and DDT at concentrations of 0.0023, 0.00023 and 0.03 mg/l, respectively.

Analysis of milk samples collected from the cows grazing near the Ak-Chabyr pesticide burial site showed concentrations of HCH and DDE ranging from 0.03 to 0.07 mg/l.

As for the Ak-Chabyr pesticide burial site, during the period 2013-2014, the Green Light NGO in partnership with the Econs Bishkek NGO, with the support of the GEF SGP KR and the leadership of the Suzak district state administration fenced the Suzak A site, dug a ditch around the perimeter (1.5x1.5) of the site, covered the opened pits with a thick film and covered them with soil on top to prevent further spread of pollution from this area (wind, precipitation), built a house for a watchman of the site. All these measures allow us to assert that the excavation of POPs from the repository will stop, but this is not a solution of problem. Of course, this is a temporary solution since there must be a decision by the government of the Kyrgyz

Republic regarding the determination of the operational manager of all pesticide burial sites. But in the conditions of southern Kyrgyzstan, pesticides from this pesticide burial site accumulate in these dug ditches along the perimeter of the site, and then through underground routes enter the groundwater; this is evidenced by the tests taken on November 26, 2013.

In rain-free period, samples collected from this underground source located in 10 km downstream from the Ak-Chabyr pesticide burial sites showed HCH-γ was 0.00012 and DDD - 0.0001 mg/l. Samples collected from this source during the rainfall period showed concentrations of HCH increased to 0.06 mg/l; DDT - 0.067 mg/l, i.e. the entry of pesticides from the pesticide burial site into surface and underground waters is obvious. Therefore, we ask international organizations and scientists participated in this forum to provide assistance in solving this problem.

When it rains, pesticides are washed away by mountain torrents. As a result, pesticides are found in neighboring settlements and farms.

Therefore, the only way is to remove these toxic chemicals from these pesticide burial sites or complete isolation by coating the surface and along the edges of the sites. Pesticides are washed away from these pesticide burial sites during precipitation period by mudflows and rain, ending up in settlements and farms located downstream the sites and the toxic flow enters the Bazar-Korgon reservoir located 15 km below the Ak-Chabyr pesticide burial site, where the measurements of HCH and DDT concentration levels showed 0.05 mg/l and 0.07 mg/l, respectively.

FIGURE 10. OVERVIEW OF THE BAZAR-KORGON WATER RESERVOIR LOCATED IN 15 KM FROM THE THE AK-CHABYR PESTICIDE BURIAL SITE

In 2010, 32 people were poisoned by consuming the meat from the cattle grazing near the pesticide burial site. They consumed fried liver and meat of sheep. Six poisoned people (3 of them were children) were examined for OCPs; DDT and DDD

FIGURE 11. FENCING OF THE SITE

were detected in the blood serum; α-HCH and β-HCH were also found but the total concentration did not exceed 0.005 mg/l.

Another pesticide burial site located in the Kok-

FIGURE 12. DESTROYED PESTICIDE STOREHOUSES

Art Valley on the territory of Tash-Baka is located at 3 km from the settlement. (See Fig.11 below).

Wheat fields are located about 10 meters from the pesticide burial site.

FIGURE 13. CHILDREN ARE PLAYING ON THE DESTROYED AND HIGHLY CONTAMINATED PESTICIDE STOREHOUSES. COURTESY OF BERTO COLLET, TAUW, THE NETHERLANDS (2007)

During the rain periods, pesticides are washed out of these pesticide burial sites by mudflows and transferred to settlements and farms located downstream the sites.

Along with pesticide burial sites, old pesticide storehouses and agro-airstrips are the source of the environmental contamination. Of the 183 sites, 135 are completely destroyed.

The severity of situation in southern Kyrgyzstan still exists because OCPs are blown away from the destroyed pesticide storehouses in summer (temperature in summer period raises up to 45ºC) and washed away by mountain torrents when it rains, penetrating and contaminating soil, surface and underground waters (Suzak region) and crop fields.

Thus, the highest level of danger of contamination of the environment and bio-environment by OCPs in the conditions of southern region of Kyrgyzstan is represented by pesticide burial sites, former pesticide warehouses and agro-air strips. To eliminate the spread of pesticide waste and highly contaminated soils from these sites it is necessary to cover the surface and isolate the edges of pesticide burial sites (temporary if no funding is available) or package them for transportation for final destruction in hazardous waste plants and treatment in soil treatment plants ovens. These plants are not available in Kyrgyzstan or in other Central Asia countries. The only perspective for these options, will be tested by FAO in Azerbaijan in trial burns in a licensed cement kiln, by the end of 2024 [4, 5] for the areas of former pesticide warehouses and agro-airstrips - soil remediation is required.

FIGURE 14: THE LOCAL POPULATION CULTIVATES COTTON AND MAIZE ON THESE SITES AND HAS A REST THERE. COURTESY OF BERTO COLLET, TAUW, THE NETHERLANDS (2007)

2. Remediation methods

Development and implementation of a soil remediation strategy [1]. Our research showed that among vegetables in conditions of southern Kyrgyzstan, the highest percentage of detection of pesticides was in onions, amounting to 82.5% and 44.3% above the permissible concentration level (PCL), against 67.2% and 4.92% in potatoes and carrots. In bell pepper - 55.5% and 33.3%; tomatoes - 36.6% and 27.3%; garlic - 35.7% and 14.3%; cabbage - 44.0% and 11.1%; radish - 31.2% and 6.25%. In turnips (66.7%) and dill (33.3%), there were no values above the PCL. Data on the detection of pesticides in pumpkin and radishes were unreliable.

TABLE 1.
DETECTION OF ORGANOCHLORINE PESTICIDES (%) IN VEGETABLES GROWN IN FORMER COTTON FIELDS AND NEAR FORMER PESTICIDE STOREHOUSES AND AGRO-AIRSTRIPS (2013)

Types of vegetables	Pesticides detected (%)	
	Detected	Above permissible
Onion	82,5	44,3
Carrot	67,2	34,92
Potato	61,2	4,92
Bell pepper	55,5	33,3
Tomatoes	36,6	27,3
Garlic	35,7	14,3
Cabbage	44,0	11,1
Radish	31,2	6,25
Turnip	66,7	-
Dill	33,3	-

As shown in Table 1, the highest pesticide detection rate was recorded in carrots and onions, the lowest - in turnips and dill. In bell peppers and tomatoes high concentrations of OCPs were detected in the seeds, but this issue requires more detailed studies.

In samples collected from vegetables grown in former cotton fields from the upper part of the garden, concentration levels of OCPs were lower than in samples collected from vegetables cultivated in the lower part of the garden. The more detailed data is shown in Table 2.

Such picture indicates that pesticides are washed away by irrigation water from the top to the bottom with the accumulation of OCPs in the lower part of garden fields.

To remediate and purificate the soil from OCPs the method of spring irrigation can be used, i.e. washing out contaminated soil with water.

The same picture was found in rice fields. In the rice paddies located at the beginning of the rice fields, no OCPs were detected from the soil; at 4-5 rice paddies downstream, OCPs were detected, but the concentration was lower compared to vegetable gardens; perhaps this was due to soil washing, flooding or sorption rice, but this assumption requires more detailed research on more material.

Concentrations of OCPs differed among the types and parts of vegetables. To study the tropism of vegetables in relation to OCPs, concentration levels of OCPs in vegetables grown near the former pesticide storehouses and agro-airstrips were studied. According to the literature data, high concentrations of OCPs were found in carrots and potatoes cultivated on chernozem (fertile soil). In our conditions (white sandy soil), high OCPs concentration levels were found in red onions and red carrots, so two types of carrots and onions were taken for the study.

TABLE 2.
CONCENTRATION LEVELS OF OCPS IN VEGETABLES DEPENDING ON THE PLACE OF CULTIVATION (THE BEGINNING PART OF THE GARDEN (THE START OF WATERCOURSE) AND FINAL PART OF THE GARDEN (THE END OF THE WATERCOURSE)

Vegetables under analysis		Soil samples							
		The beginning part of the garden				The final part of the garden			
		Number of samples	Number of positive	%	Concentration level (mg/kg)	Number of samples	Number of positive	%	Concentration level (mg/kg)
1	red carrots	7	5	71,4	0,01-0,085	6	6	100	0,09-0,15
2	yellow carrots	7	3	42,9		5	3	60	
3	red onion	8	6	75		7	7	100	
4	white onion	7	4	57,1		7	6	85,7	

When studying the concentration of OCPs, the highest concentration level of OCPs was found in the root part of carrots, and in the underground part of onions (it was 2-3 times higher than that in the middle part).
Moreover, OCPs concentration levels differed among carrot and onion types. Concentration levels of OCPs in red carrots were 2-3 times higher than those in yellow carrots, and 10 times higher compared to potatoes that corresponds to the literature data.
Concentrations of OCPs depended on the part of the vegetables. The root top and end parts of carrots contain more OCPs than the middle part. Onions in the underground part contain two to three times more OCPs than in the middle part. Red carrots and red onions are therefore can be used for soil remediation in southern Kyrgyzstan.

TABLE 3.
TOTAL CONCENTRATIONS OF OCPS IN VARIOUS PARTS OF VEGETABLES TAKEN FROM FORMER AGRO-AIR STRIPS.

Vegetables	Part		
	Above ground (1)	Middle (2)	Underground (3)
red carrots	1,8 mg/kg	0,012 mg/kg	0,45 mg/kg
yellow carrots	0,8	0,06	0,2
red onion	0,095	0,03	0,84
white onion	0,07	0,02	0,14

The high OCPs detection rate in red carrots may be due to the high concentration of carotene, which sorbs more OCPs; in red onions this is due to strong roots and red "color", but this issue requires more detailed research. All vegetables grown in the former cotton fields, near the former pesticide storehouses and agro-airstrips must be tested for OCPs. Continuous monitoring of soil contamination, carrots and red onions are required.
Thus, in conditions of southern Kyrgyzstan, the highest OCPs detection and concentration rates were found in red carrots and red onions, the lowest - in turnips and dill. Concentration levels of OCPs depended on the parts of garden where they were cultivated: the upper part of the garden contained less OCPs than the lower part.
Bioremediation and phytoremediation methods are cost-effective, efficient, eco-friendly and they may become a good alternative to more expensive and toxic chemical and physical methods.
Former pesticide store in Chem-Korgon village was used as a place for testing the efficacy of bioremediation. Three conditions were tested: application of fertile soil and bioproduct, application of fertile soil but no bioproduct (Control 1), and no fertile soil and no bioproduct (Control 2). The treatment was applied directly to the contaminated soil. For the bioproduct three bacterial species (*L.ysinobacillus fusiformis* (SA-4 strain), *Stenotrophomonas sp*. (Ps-B strain) *and E. cloacae* (SB-2 strain) were used. The most effective conditions, in terms of pesticide degradation, was the application of fertile soil and bioproduct. The degradation using this condition was 1.5 to 2 times higher than when only fertile soil was added (and no bioproduct) and 5 times higher than when no fertile soil and no bioproduct were added. Using the association of active degrading bacteria and improving the agrochemical conditions of the soil made it possible to remove obsolete pesticides within 6 months, their concentrations ranging from 0.41 mg minimum to 15.21 mg maximum per kg of soil. The trials showed that degradation of pesticides by microbes depends not only on the bacterial system but also on the conditions like

temperature, pH of soil, moisture contents and nutrients [2].

Bioremediation and phytoremediation technology for soils contaminated with obsolete pesticides was also applied in the former airfield in the village of Chym-Korgon. Crop seeds (Zea mays, Triticum aestivum, Beta vulgaris) were pre-treated with a biopreparation "ROSTIN" which was based on cultures of live soil streptomycetes (Streptomyces fumanus) and sown on the experimental plot. The abundant growth of the plant and the reduction of phytotoxicity of the soil were recorded. A marked decrease in concentration levels of obsolete pesticides was observed [3].

To remediate OCPs polluted soils in southern Kyrgyzstan, red carrots and red onions can be used. Please not that it is absolutely forbidden to consume any vegetables that are used to remediate contaminated soils. All the vegetables and plants used for soil remediation are to be collected in specially arranged places and then to be destroyed so cattle and local population have no access to it.

The results of bioremediation projects [2,3] recently implemented in Kyrgyzstan showed that application of fertile soil and the bioproduct was effective for pesticide degradation.

Bioremediation and phytoremediation are thus can be considered a good alternative to more expensive and toxic chemical and physical methods in Kyrgyzstan.

References

1. Toichuev R.M., Khametova M.Sh., Rakhmatillaev A., Madykova Zh.A., Paizildaev T.R. Environmental pollution with organochlorine pesticides in conditions of southern Kyrgyzstan and possible ways of using vegetable cultivation and irrigation for soil remediation. Materials of the IV International Scientific Environmental Conference "Problems of reclamation of household, industrial and agricultural wastes" Krasnodar. March 2015, pp. 458-461
2. Doolotkeldieva, T., Konurbaeva, M., Bobusheva, S. In situ implementation of trials on microbiological remediation of POPs contaminated soils in Kyrgyzstan (SUMB). 14th international HCH&Pesticides Forum Book. (link to the presentation)
3. Doolotkeldieva, T. D., Konurbaeva, M. U., Bobushova S.T. Application of the method of phytoremediation of pesticide contaminated soils in a field experimental plot in Chim-Korgon village. 14th International HCH&Pesticides Forum Book. (link to the presentation)
4. Santivanez, T. General overview of FAO work on pesticides management and environmental sustainability in Europe and Central Asia (link to the presentation on 14th international HCH& Pesticides Forum Book).
5. Robinson, S. Inventories and assessment of regional disposal options. 14th international HCH&Pesticides Forum Book.