Pesticide use in rice cultivation in Tarapoto, Peru

Usage patterns and pesticide residues in water sources

Master's thesis by

Britta Palm

Department of Environmental Assessment
Swedish University of Agricultural Sciences
PO Box 7050
SE-750 07 Uppsala, Sweden

Supervisors: Henrik Kylin and Cesar Chappa Santa Maria

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Resumen (Spanish Abstract)

Se realizó un estudio sobre el uso de plaguicidas en cultivos de arroz en la ciudad de Tarapoto, Departamento de San Martín, Perú. Dicho Departamento ocupa el segundo lugar respecto de la producción de arroz en Perú con un gran aporte de plaguicidas y consumo de agua. Se utilizan grandes cantidades de plaguicidas, clasificados como Altamente Peligrosos según la Organización Mundial de la Salud. Incluso aquellos que no han sido formulados o recomendados para arroz. Este estudio forma parte de un proyecto interdisciplinario mayor. Particularmente, los objetivos de este estudio fueron identificar el uso de plaguicidas entre los productores de arroz, así como también, identificar las vías de los plaguicidas en el medioambiente mediante análisis de aguas.

Con el propósito de comprender la condición socioeconómica, identificar las prácticas de cultivo y caracterizar el uso de pesticidas se llevaron a cabo entrevistas semiparticipativas entre siete productores, utilizando técnicas de Diagnóstico Rural Participativo (DRP) y Valoración Rápida Rural (VRR). Adicionalmente, a través de estos resultados, se identificaron los lugares aptos para la recolección de muestras de agua.

Se colectaron veinticuatro muestras de agua desde arroyos, canales de regadío, parcelas de cultivo. Así como también de la napa freática. Se utilizó la técnica de Extracción de la Fase Sólida (EFS). Mediante cromatografía de gases utilizando un detector de captura de electrones, se determinó la concentración de diferentes plaguicidas tanto en solución como adsorbidos a partículas en suspensión. Para determinar distintos compuestos se contó con 23 sustancias de referencia.

Según el resultado de las entrevistas, la totalidad de los encuestados manipuló sustancias de plaguicidas al menos en la preparación o en la aplicación. Mientras que todos realizan la limpieza de la motobomba en fuentes cercanas de agua como canales de regadío o arroyos. Por otra parte, seis de los siete agricultores almacenan los plaguicidas dentro en el mismo lugar donde habitan. Se registró que cinco han presentado síntomas de intoxicación y ninguno de los siete utiliza el equipo protector recomendado. Los plaguicidas más frecuentemente utilizados son *Tamaron* y *Thiodan*, cuyos ingredientes activos son metamidofos y endosulfan respectivamente.

En las muestras de agua se detectó α- endosulfan, β-endosulfan, endosulfan-sulfate, butacloro, paration-ethyl, alfa-cipermetrina, DDT-o,p, DDE-p,p, DDD-p,p, metamidofos, carbofuran, y carbosulfan. Sin embargo, la concentración de metamidofos, carbofuran y carbosulfan no pudo ser determinada debido a contaminación del tratamiento cero. Situación que afectó tanto a las muestras en solución como en suspensión. Tanto el endosulfan (α- y β-), como el producto de su degradación: endosulfan-sulfato, fueron las sustancias más detectadas en segundo lugar. Butacloro fue detectado principalmente en arroyos y alfa-cipermetrina solamente en una parcela de cultivo imediatamente después aplicación con la sustancia. Se detectó Parathion-ethyl en el arroyo Mishquiyacu y a la vez en un canal de regadío. Salvo para butacloro and alfa-cipermetrina, las concentraciones registradas de otras sustancias no sobrepasan 1 µg/l, manteniéndose en niveles similares entre sí.

A pesar de la baja cantidad de material particulado en suspensión, fue posible detectar sustancias plaguicidas en él. A parte de metamidofos, carbofuran, carbosulfan se detectó α- endosulfan, β-endosulfan, endosulfan-sulfato, alfa-cipermetrina y DDT-p,p.

Los resultados muestran que todos los agricultores incluidos en el estudio utilizan los plaguicidas de una manera insegura e inadecuada. No existe correlación entre el número de aplicaciones por cosecha y las concentraciones detectadas en el estudio. Así mismo, la ubicación de las laterales de riego y la posición de las parcelas de cultivo en el campo no se correlacionan con las concentraciones halladas. Los caudales de ingreso y de salida en el sistema de riego son bastante impredecibles y el área posee problemas de escasez de agua.

Palabras claves: Residuos de plaguicidas, fuentes de agua, arroz, Tarapoto, Perú, EFS, GC-ECD, DRP/VRR, manejo de plaguicidas, Tamaron, Thiodan, metamidofos, carbofuran, carbosulfan, endosulfan, alfa-cipermetrina, DDT, butacloro, parathion-ethyl

Abstract

A study concerning the use of pesticides in rice cultivation was performed in the Tarapoto-region, department of San Martín, Peru. The department is the second most important rice production in Peru with a large in-put of pesticides and water consumption. Large amounts of pesticides classified by WHO as highly hazardous are used, even those that are not manufactured or recommended for rice. This study was a part of a larger interdisciplinary project. The objectives in this specific study were to identify the usage of pesticides among rice farmers in the study area, and to identify pathways for pesticides by analysing water sources for pesticide residues.

Semi-structured interviews with PRA/RRA tools took place with seven voluntary rice farmers. The aim of the interviews was to understand the socio-economic conditions, found out about rice cultivations practices, the usage patterns of pesticides and to identify suitable water sampling sites.

Twenty-four water samples in total were collected from irrigation canals, surface waters, groundwater, and field waters. The Solid-Phase Extraction (SPE) technique was used, and the water and filter samples were analysed on GC-ECD after extraction, and screened for 23 active ingredients.

According to the interviews, the seven farmers included in the study were handling pesticides in the same way. All farmers sprayed or mixed the pesticides, and washed the backpack sprayer in irrigation canals or surface water. Six of the seven store the pesticides in their living quarters. Five farmers have had symptoms of intoxication and no one used recommended protective equipment. The most commonly used pesticides are *Tamaron* and *Thiodan* with the active substances methamidophos and endosulfan respectively.

In the water samples were α- endosulfan, β-endosulfan, endosulfan-sulfate, butachlor, paration-ethyl, alpha-cypermethrin, DDT-o,p, DDE-p,p, DDD-p,p, methamidophos, carbofuran, and carbosulfan detected. Methamidophos, carbofuran and carbosulfan were detected in all samples in the study, but there concentrations could not be determined due to a contaminated blank sample. The endosulfans (α- and β-) and its degradation product endosulfan-sulfate was the second most detected compound. Butachlor was mainly detected in surface waters and alpha-cypermethrin was only detected in a special case from a field right after spraying with the substance. Parathion-ethyl was detected in the stream of Mishquiyacu and in an irrigation canal. The results from the study are fairly similar where no concentrations reach 1 µg/l, except for butachlor and alpha-cypermethrin.

Pesticides bound to particle from the filters were detected despite the low content of particles. Besides methamidophos, carbofuran, carbosulfan, were also α- endosulfan, β-endosulfan, endosulfan-sulfate, alpha-cypermethrin and DDT-p,p, detected.

The results show that all the farmers in the study are using the pesticides in a manner that is both unsafe and inadequate. There is no correlation between the numbers of applications per harvest and concentrations detected in the study. There are neither correlation between from which lateral the fields are irrigated, the allocation of the field and the results. The in- and out flow of water in the irrigation system is fairly unpredictable, and the rice producers have problem with water scarcity.

Keywords: Pesticide residues, water sources, rice, Tarapoto, Peru, SPE, GC-ECD, PRA/RRA, usage patterns, Tamaron, Thiodan, methamidophos, carbofuran, carbosulfan, endosulfan, alpha-cypermethrin, DDT, butachlor, parathion-ethyl

Abbreviations

a.i. Active ingredient

ATDR Administración técnica del distrito de riego/ Technical administration for drainage

CIP Centro Internacional de la papa/ Internacional Potato Center

CVR Comisión de la Verdad y Reconciliación/ Truth and Reconciliation Commission

DDE 1,1-dichloro-2,2-bis(p-chlorophenyl)ethane (degradation product to DDT)

DDD 1.1-dichloro-2.2-bis(p-chlorophenyl)ethylene (degradation product of DDT)

DDT Dichloro-Diphenyl-Trichloroethane (1,1,1-trichloro-2,2-bis(p-chlorophenyl)ethane)

DT_{50} Half-life factor

EFED Environmental Fate and Effects Division

EQS Environmental Quality Standards

GC-ECD Gas chromatograph with electron-capture detector

GDP Gross Domestic Product

GEF Global Environment Facility

HCB Hexachlorbenzene

HCH Hexachlorocyclohexane

IIAP Instituto de Investigaciónes de la Amazonia Peruana/ Institute of Investigation of the Peruvian Amazon

IMA Institutionen för Miljöanalys/ Department for Environmental Assessment

IMR The Infant Mortality Rate

INEI Instituto Nacional de Estadística e Informática/ Peruvian Institute for Statistics and Information Techonology

INIEA Instituto Nacional de Investigación y Extensión Agraria/ National Institution of Agrarian Investigation and Extension

INRENA Instituto Nacional de Recursos Naturales/ National Institution of Natural Resources

IPCS Internacional Programme on Chemical Safety

IRET-UNA El Instituto Regional de Estudios en Sustancias Tóxicas de la Universidad Nacional en Costa Rica**/** The regional institute for toxic substances, Nacional University of Costa Rica

KemI Kemikalieinspektionen/ Swedish Chemical Agency

K_{oc} Soil-water partition coefficient

K_{ow} Octanol-water partition coefficient

LC-MS Liquid chromatography – mass spectrometry

MFS Minor Field Study

MINAG Ministerio de Agricultura/ The Ministry of Agriculture

MS Mass spectrometer

NAS/NAE National Academy of Sciences and the National Academy of Engineering (U.S.A)

NILU Norsk Institutt for luftforskning/ Norweigan institute for Air Research

PAN Pesticide Action Network

PEAH Proyecto Especial Alto Huallaga/ Special project of Alto Huallaga

PEAM Proyecto Especial Alto Mayo/ Special project of Alto Mayo

POP Persistent Organic Pollution

PRA/RRA Participatory Rural Appraisal/Rapid Rural Appraisal

PSD Pesticides Safety Directorate

RAAA Red de acción de Agricultura Alternativa/ The Network for an Alternative Agriculture

REACH Registration, Evaluation, Authorization and Restriction of Chemicals

SENAMHI Servicio Nacional de meterología e hidrología dirección regional San Martín/ National Service of meteorology and hydrology

SENASA Servicio Nacional de Sanidad Agraria/ National Agrarian Sanitary Service

Sida/Asdi Swedish International Cooperation Development Agency/ Agencia Sueca de Cooperación para el Desarollo

SLU Sveriges Lantbruksuniversitet/ Swedish University of Agricultural Sciences

SPE Solid Phase Extraction

SRC Syracuse Research Corporation

UNDP United Nations Development Programme

UNSA Universidad Nacional de San Martín/ National University of San Martín

USEPA U.S. Environmental Protection Agency
WFD Water Framework Directive

WHO World Health Organization

WFP World Food Program

WQD Water Quality Criteria

Spanish expressions

Almácigo Riceplantnursery

Arroz Rice

Cabrilla Agricultural practice, the rice plants are left after harvest and are let to grow again

Peón Daypaid worker/farmhand

Table number

Figure number

All photos are taken by Britta Palm if not otherwise stated

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1. Aim and objectives

This report is one of three in a larger interdisciplinary study.
The aims of this particular report are:

- To identify the usage patterns of pesticides among rice farmers in the districts of Morales and Cacatachi, Tarapoto-region, Peru

- To identify pathways for human exposure to pesticides by analyzing water sources for pesticide residues

The principle objective of this interdisciplinary MFS-project was to get a better understanding of the situation in Tarapoto. The problems concerning the massive use of pesticides in the study site are too complex to be dealt with using knowledge and methodology of just one discipline. In addition to this report, Gun Lange covered the levels of some pesticides in human blood, and Agneta Andersson studied the business economics.

2. Introduction

2.1 Background

In 1999, 24 schoolchildren died and an additional 20 were seriously intoxicated in Tauccamarca in the department of Cusco, Peru, after having been accidentally exposed to the pesticide parathion in their food. This is only one of many accidents that occur throughout the world each year.

The last decade, agricultural production has increased greatly in developing countries in the tropics. Simultaneously with the expansion of agriculture, the use of pesticides has also increased drastically. Latin America is becoming one of the fastest growing markets for agrochemical (Agrow Reports 1996). Pesticide sales in Latin American increased 30% from 2003 to 2004. A high proportion of the sales are of old, more hazardous products (Brodesser et al. 2006). The explanations for the expansion are market liberalisation, growing international trade alliances, relative political stability, and an increase of investments in cultivation systems based on an intense use of agrochemicals.

At present farmers worldwide lose 42% of their crop to pathogens, insects, and weeds. The loss would be nearly 70% without modern technologies (Brodesser et al. 2006). It is necessary to use pesticides in the developing countries, but in many cases the pesticides are used in an inadequate way. Although most of the pesticides are used in the industrialized countries, the large majority of intoxication cases occur in the rural areas in the developing countries.

The rice fields in the Tarapoto region, San Martín, in the northern highlands of Peru are no exception from the increased use of pesticides. Great amounts of insecticides, herbicides and fungicides are used and spread on the rice fields. The intensive use of pesticides, the way in which they are applied, the toxicity of the compounds used, the drainage systems of the rice fields, and heavy tropical rains, are factors that combine to threaten the aquatic ecosystem of the area. Furthermore, the high exposure of very toxic chemicals, and lack of user information, protective equipment and education, may give rise to negative health effects among the inhabitants. The health centres in the region receive cases of pesticide poisoning every month, and approximately three cases every year where pesticides have been used to commit suicide. Pesticides are easily accessible in most developing countries, and because of this pesticide poisoning is the most common way of committing suicide (Eddleston et al. 2002).

The consequences of the intensive use of pesticides are many and may also be a consequence of intensive marketing by big multinational companies. It is still possible to produce and export agrochemicals that are banned in the country of production. In 1985, FAO implemented a voluntary Code of Conduct for the pesticide industry in an attempt to decrease the negative effects caused by pesticides. According to the Code of Conduct, highly toxic pesticides should not be exported to developing countries where a safe use cannot be guaranteed. Unfortunately, many companies do not follow this code. Lack of adequate government resources in many developing countries makes the Code of Conduct ineffective (Eddleston et al. 2002).

Due to the limited resources to handle them, the problems with pesticides in developing countries are multiple. Unfortunately the health and environmental problems caused by the large use of pesticides are drowning among other societal problems of Peru – problems like poverty, economic crisis, high criminality, terrorism, corruption, and natural disasters.

2.2 Peru

Peru with its 1 285 000 km^2 is the third-largest country in South America and almost three times the size of Sweden. More than 30% of the population of 26 000 000 inhabitants live in the capital Lima (INEI 2005). The population growth per annum is 1.4% (UNDP 2006) and the main industries in the country are mining, fishing, metallurgy, textile, chemical, and energy. Agriculture and cattle raising are other economic activities.

Peru is divided into three geographical regions: the coastal desert, the Andean highlands, and the Amazon jungle. The climate varies greatly between these regions.

The major cities and most of the population are within the narrow desert along the coast, *la Costa*. Rivers from the west sides of the Andes crosses the desert forming oases with advanced agriculture. River deposits of sediment from the highlands have made the soils in the valleys very fertile and excellent for agriculture. Irrigation plays an essential role in supporting the coastal cities with agricultural produce. The main products from the coast are cotton, rice, sugar, fruits, wine, and minerals (Peru traveller guide 2007-05-11).

The Andean highlands, *la Sierra*, consist of three parallel mountain chains, the Eastern, Central, and Western Cordilleras. The altitudes range from around 2000 m above sea level to Peru's highest mountain of Huascarán that reaches 6768 m. Peru is situated in an earthquake zone. In 1970, 70 000 people were killed as a result of a strong earthquake west of Chimbote, in the central coast of Peru. Although most of the Peru's Andes lie between 3000-4000 metres above sea level a big part of the population live here (Lonely Planet 2000). The main agricultural products are potatoes, cereals, and vegetables, and cattle, with additional important activities like mining and weaving. Due to poor living conditions and political instability caused by the Maoist group *Sendero Luminoso* (the Shining Path), a large part of the population in the highlands have migrated to the coast that has lead to overpopulation problems in the coastal cities.

The Amazon jungle, *la Selva*, on the east side of the Andes, covers almost 60% of the country. Few roads penetrate this region and only 5% of the population live here. La Selva is drained by large rivers like Marañon, Huallaga and Ucayali, tributaries to the Amazon. The precipitation is high in the area and the soils are nutrient poor due to heavy weathering. Wood is the principal product, as well as rubber, rice, fruits, coffee, tea, petroleum and natural gas.

The population of Peru is an ethnic mixture of 54% native Americans, 32% Mestizos, 12% ”white” of Spanish decent and 2% of black and Asian minorities. Spanish and Quechua are the two official languages. Spanish is the main administrative language, but Quechua is widely spoken in the highlands and also the native language of Aymara is spoken around Lake Titicaca. The Amazon part of the country has a large diversity of native languages belonging to different ethnic groups (Nationalencyklopedin 1994).

During the late 1980s and early ´90s Peru struggled with economic problems, e.g., extremely high inflation and a large foreign debt. This opened for dissatisfaction among the population and opened doors for the guerrilla groups *Sendero Luminoso* and the Cuban inspired MRTA (*Movimiento Revolucionario Túpac Amaro*). One hypothesis about the formation of the groups is that it came as a response to Peru's system of race- and class-based discrimination that mainly affected the indigenous population. Both the guerrilla groups advocate violence against the central government and were classified as terrorist organizations, with *Sendero Luminso* as the bigger and more violent. The guerrilla groups used Peru's peasantry to grow coca to further their profits and to fund their war. After aggressive antiterrorism politics and the capture of guerrilla leaders during the 90´s the terrorism declined drastically. In combating the guerrilla groups, the Peruvian armed forces frequently used excessive force and many innocent civilians were killed. The former President of Peru, Alejandro Toledo, formed a Truth and Reconciliation Commission in 2003. The Commission reported that since the 80´s when the guerrilla groups took up arms, the total number of deaths and disappearance were 69 280 (CVR 2003). Both *Sendero Luminoso* and MRTA are still active, mainly in the central part of the country, and unfortunately the terrorist activity has risen significantly in the country recent years. Due to the increase in terrorist activities the government has re-initiated preventive efforts similar to those which were implemented twenty years ago (Living in Peru 2007). Peru's recent history is characterized by periods of democracy and a sustained and fairly strong economic growth. The Gross Domestic Product (GDP) in 2004 increased by 4.5%. Despite this, the country has large economic problems, and poverty is widespread. In 2002, the number of poor was 54.3%, and of those 23.9%

lived in extreme poverty (Sida 2004). In June 2006, the former president from the 80´s Alan García was re-elected.

Map 1. Peru with San Martín (www.geocities.com/tarapoto_peru/)

2.3 The study site, San Martín

The project was carried out in the districts of Cacatachi and Morales, which are situated close to the city of Tarapoto in the northern highlands of Peru. Tarapoto is situated 06° 31' 30" S, 76° 21' 50" W, at 353 m a.s.l. in the province of San Martín in the north-eastern part of the Department of San Martín. The department San Martín has an area of 50 435 km^2 (Encarnación 2005) and a population around 670 000 (INEI 2005), of which 110 000 live in Tarapoto which is the biggest city in the department. Tarapoto is divided in three parts; Tarapoto, La banda de Shilcayo and Morales. The study site is in the catchment area of the Cumbaza River. The main vegetation in the catchment area is dry highland forest and there are severe problems with deforestation due to increased agriculture and illegal logging activities. According to grupo técnico de la ZEE in San Martín, is around 25% of the area of San Martín is deforested (Ramírez 2005). The most part of the Department San Martín is affected by severe or very severe by human induced soil degradation according to soil degradation maps made by FAO/AGL (FAO/AGL 2007-05-11).

2.3.1 The population and the economy

Approximately 52% of the population in the Department San Martín works in the agricultural sector, and as in many developing countries the informal sector is large. Projects like PEAM and PEAH have been implanted to induce a positive economical development in the region (Limachi 2005). Of the population, 10.4% is illiterate and the percentage is even higher in the rural areas (ATDR 2006). In the department, 65%

of the population live in urban areas and according to INEI around 72% live without their basic needs fulfilled **(**INEI 2005). Tarapoto is the economic centre of San Martín although the city of Moyobamba is the capital of the department. The main road, *la Carretera marginal*, which connects the Peruvian coast with the jungle, was constructed during the 60´s. The new road induced a large immigration flow to the region from other parts of the country, especially from the Andean highlands. From 1981 to 1993 the population in San Martín increased with 72% (Limachi 2005). The highest population growth occurred in the provinces of San Martín where most of the illegal coca production took place. The population in Tarapoto for example grew with 4.6-5.7% per year during 1981-1993. Farmers started to cultivate coca as their main crop since the demand was high by narco-trafficking groups and insurgents. During the late 80´s and in the beginning of the 90´s the department had large problems with drug-trafficking and terrorism that had a negative effect on the development (Limachi 2005). Peru is the first link in the cocaine production chain by cultivating the coca leaf, whereas the processed cocaine usually originates from the neighbouring countries Bolivia and Colombia. Guerrilla groups had and still have a quite big influence in the area downstream the river of Huallaga. Unfortunately since the main coca combat has been focused to Colombia, the coca production in Peru increased with 40% during 2005 (TT 2006). During recent years, the region Tocache in San Martín in intervals has been classified as an emergency zone because of increased terrorism activity by *Sendero Luminoso* .

The Infant Mortality Rate (IMR, Table 1) differs substantially between Peru and its neighbouring countries. The IMR is very high in the department San Martín with 60.5 deaths of 1000 live births (ATDR 2006). Peru has an IMR of 31.94 in total. The IMR rate in San Martín is similar to Kenya with 61.47 and can be compared to Sweden with 2.43. Unfortunately, the high IMR in San Martín reflects the general level of health and nutrition. These are often affected by water quality, housing quality, and the low level of education, especially among women. In San Martín, one reason may be that cash crops like coca have replaced traditional food production leading to malnutrition.

Table 1. Comparison of the IMR in San Martín, Peru in total and the neighbor countries (The World Factbook 2005)
*(ATDR 2006)

Country	IMR (Number of deaths during the first year of life per 1000 live births)
Department of San Martín, Peru*	60.5
Bolivia	53.11
Peru in total	31.94
Brazil	29.61
Ecuador	23.66
Colombia	20.97
Chile	8.8

2.3.2 The climate

San Martín is divided in three parts geographically depending on the climate, the Highland jungle (Selva Alta) the Lowland jungle (Selva Baja) and the Central jungle (Selva Central). The city of Tarapoto is situated in the Selva Alta region and according to the Thornthwaite classification the study site has a semi-dry tropical climate without excess of water through the year (Vargas 2005). The temperature generally fluctuates between 19 and 34 °C, and the precipitation varies between 800-1200 mm/year. October to April has the highest precipitation where usually April is the month with most rain (SENAMHI 2006).

The relative humidity usually varies between 70% and 80% (Appendix XI) and the average wind velocity from north is 0.9 m/s and from south 1.75 m/s (ATDR 2006). In 2005 the rain was delayed, which led to that there was less rain than usual in the month of July and August. The average maximum temperature in August was more than 1 °C higher than normal and the average relative humidity around 6.5 % lower (Appendix XI). The heavy tropical rains at the study site can lead to problems with big losses of pesticides in surface run-off and by leaching.

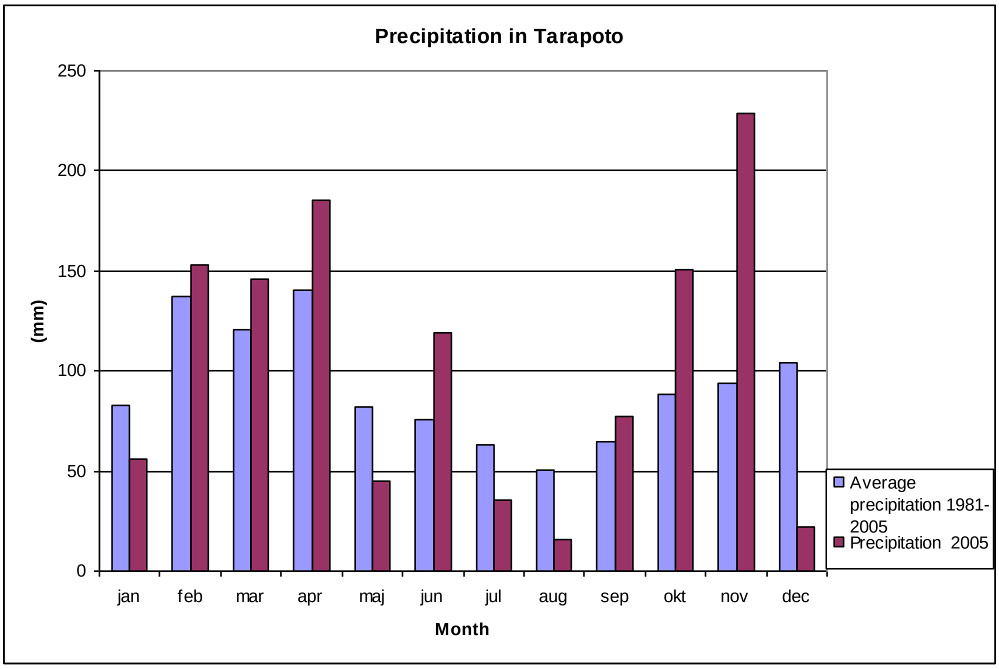


Figure 1. The precipitation in Tarapoto Source: SENAMHI, San Martín

2.3.3 Water balance

In Tarapoto there is a deficit of total 367 mm of water between the months of June to February. The water balance is calculated with an accumulation of water in the soil of a maximum of 100 mm. Between March and May the real evapotranspiration is the same as the potential evapotranspiration. There is a small recharge of humidity to the soil during March and April, the months in which the precipitation is higher than the potential evapotranspiration (Vargas 2005).

2.3.4 Surface water

The Cumbaza River, which runs through the study site, is of third order and starts in the mountain of Cerro Escalera, where also the drinking water for the District of Tarapoto is collected. Cumbaza is 59.84 km long and has a catchment area of 58 718 ha. It flows into River Mayo, which flows into the Huallaga, a tributary river to the Amazon. The average flow of the Cumbaza during the month with most rain fluctuates between 70 and 120 m^3/s. In 2001 the flow reached extreme values that fluctuated between 600 and 900 m^3/s during those months. The reason for this was the climatic phenomenon *El Niño* (ATDR 2006). The common opinion among the people in Tarapoto is that the water in Cumbaza has decreased significantly the last decade. Figure 2 shows the average flow of water every month through a normal year.

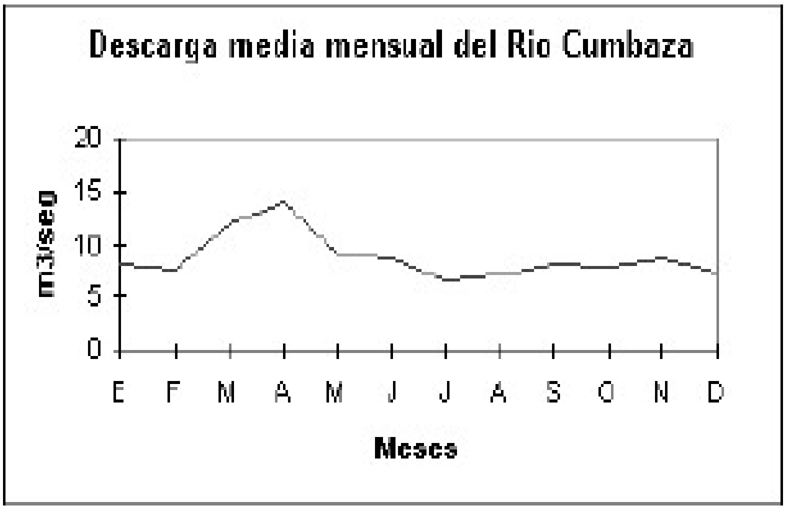


Figure 2. The average flow of the Cumbaza River through the year. The peak flows follow the rain pattern and are reached in April and November. Source: ONER 1984

Appendix X shows some characteristics of the water from the Cumbaza River and the stream of Mishquiyacu. Puente San Antonio is close to Cerro Escalera before the Cumbaza River passes through the areas with rice fields. Cacerio Juan Guerra is situated after Cumbaza has passed through the study site and Tarapoto, close to where it flows into the River Mayo. The water characteristics of those sites represent the sampling sites of sample 21 respective 24 in the study. Water sample 9 is collected from the stream of Mishquiyacu. The water characteristics between the different sites are normal and similar except for the salinity and the parameters connected to it. The high salinity in Mishquiyacu is explained by the high content of salt minerals in its catchment area (Maco Hidrografía 2005). It is surprising that the sampling site at Cacerio Juan Guerra has the highest value of dissolved oxygen as it also had observably high amounts of organic material. The temperature and pH show big fluctuation depending on if there are high or low water levels in the streams. These differences can have big influence in the degradation of toxic substances like pesticides.

In 1985 the irrigation canal of Cumbaza was constructed and led to a changed agriculture in the area. The principle irrigation canal, *Canal madre* of Cumbaza starts at the Boca toma and the water are then led into 29 laterals of first order. The distribution system of water is complex where also natural streams are included. The main canal is 58 km long and is designed for a maximum flow of 3.5 m^3/s (ATDR 2006). During the sampling period for this study, the principle irrigation canal was under reconstruction, which led to a different water flow and a more restricted use than usual. Water from Cumbaza is used to irrigate 2160 ha (ATDR 2006) of land where rice is almost the only crop. To produce 1 kg of unpolished rice 4 m^3 of water are needed. To cultivate 1 ha of rice during one season 20 000 m^3 of water are required (Chappa 2006). The great water demand of the rice fields led to restrictions and increased control of the use of water in the area. The distribution of the irrigation water from Cumbaza River is controlled by four irrigation commissions, Comisión de Regantes Cumbaza, Bajo Cumbaza, Chupishiña, and Shilcayo. The study site is situated in the irrigation area controlled by the commission of Cumbaza that is divided into nine irrigation committees. The farmers included in the study were members of the committee of Rosanayco except for one that was member of committee Primero de Octubre. Rosanayco is the biggest committee in the catchment of Cumbaza with 460 ha of irrigated land and 192 users. Most of the farmers in the catchment area are small landholders where 82% of the farmers have less than 4 ha of land (ATDR 2006). All members in the irrigation committees have to pay a fee of around 50 Soles/ha (12 Euro/ha) and cultivation season for the irrigation water.

The decreasing water in the river has also led to restriction in tap water use in Tarapoto, where the water is turned of in parts of the city at different times. The water from Cumbaza is used for drinking, irrigation, fishing, aquaculture and cleaning and hence it is very important for the people. Wastewater from the communities of Morales and Cacatachi, and run-off water from other activities like refuse dumps, chicken, pig, and cow farms, fish ponds and from the rice fields all end up in the Cumbaza River. Almost 65% of the water that provide water for the fishponds in the San Martín-region come from irrigation canals connected to rice fields (Maco Hidrobiología, 2005). This may be precarious, as the pesticides used on the rice fields may affect the fish, either by direct toxicity or bioaccumulation in fish tissues. An investigation made by the Ministry of health in 2003 shows that both water from Cumbaza and water for domestic use are contaminated with thermo-tolerant coliform bacteria (ATDR 2006).

2.3.5 Soil description

The soils in the catchment area of River Cumbaza are diverse, but most are alluvial deposits from the river. According to a study made by Grupo técnico de la ZEE in San Martín, is the dominated soil type within the study site a *Typic Udifluvents*. The soil has locally got the name Huallaga I (Escobedo 2005). Characteristics among others for a Typic Udifluvents are that they are young soils developed in alluvial deposits with weak horizontal differentiation and that they are formed in recent water-deposited sediments, mainly on flood plains, alluvial fans, and river deltas. It is common that Typic Udifluvents are wet in all or part of the profile due to stagnant water and/or flood water from rivers or tides. Submerged or waterlogged soils exclude oxidation that slows down the weathering. The chemical properties are influenced by the reduction and oxidizing conditions due to flooding (USDA, Soil Taxonomy 1999).

Classification	Order	Suborder	Great group	Sub group
Typic Udifluvents	Entisol	Fluvic	Udic	Typic
Comments	Little soil development	Floodplain	Soil moisture and temperature regimes: Humid, not dry during most of the year	

Table 2. Classification and comments of the soil in the study site

2.3.5.1 The soil at the sampling site

The soil at the study site is young and evolved from river sediments from the Cumbaza River. The drainage is classified as moderate although Field number 3 shows signs of bad drainage in the form of redoximorphic features such as precipitated iron in mottles. The systems of terraces in the catchment area also include the riverbanks (ATDR 2006). The soil from Field 6 has a neutral pH and a low content of organic material (Appendix XII). The low content of organic material induces a slower degradation of pesticides and increases the risk of soil erosion. Because of the erosion, pesticides that have accumulated in the soil can be further dissipated. However, the risk of erosion and further dissipation of the pesticides is relatively small as the slope is small, < 2%. Most of the rice fields in the districts of Cacatachi and Morales are located on flatlands. This is revealed in the place name Cacatachi, which in Quechua means plain (*Caca*) land (*tachi*).

Paddy rice cultivation is widespread on fluvent soils in the tropics. Usually with proper irrigation and drainage. The rice fields should be dry for at least a few weeks every year. The reason is to prevent the soil's redox potential from becoming so low that nutritional problems (iron, H_2S) arise. Sulphate can be reduced to H_2S, which is toxic at very low concentrations. Periods with dry land do also increase the microbial activity and stimulates decomposition of organic matter (FAO 2001).

2.3.6 The rice production

There are around 90 000 rice producers in Peru, cultivating a total of approximately 350 000 ha of rice annually. The consumption of rice in Peru has increased from 13 kg per person and year in 1950 to 54 kg in 2002 due to the large-scale introduction of rice and the low price (Palacios 2002). In the department San Martín there are around 8000 rice farmers that cultivate around 44 000 ha (Chappa 2006). More than half of the population in San Martín are farmers and agriculture is the most important source of income (Limachi 2005). The principal crops are rice, maize, and coffee, but also tobacco, cotton, cacao, oil palms, and plantains are important. San Martín has been widely affected by the green revolution and different booms. Coca, coffee and rice have all been subjects for booms and implemented on big fields with monoculture and with high demand for water, fertilizer and pesticides. In Tarapoto the most important crop is rice, and the money the rice cultivation generates plays a big role in the local economy. There are approximately 3355 ha of rice fields in the catchment area of Cumbaza. In Peru, 93% of the rice is cultivated with irrigation systems and in San Martín is this percentage even higher (Alva 2000). The construction of the Cumbaza irrigation canal in 1985 was a major historical event for the farmers in the Tarapoto region. The canal made it possible to cultivate crops with a high water demand, and started the rice boom. Many farmers started to monocultures of rice instead of cultivating traditionally crops like cassava, plantain, corn, beans etc. in an attempt to get a higher income. The pesticides where introduced at the same time as the monoculture systems, but many of the rice farmers initially, because of the cost, did not use pesticides. But as the pest problems increase the longer monoculture practices are used, essentially all farmers now use pesticides (Torrejón 2003).

In most of the department it is possible to harvest twice a year. The yields depend on the time of the year, the rice type and on the site, and vary from 5.5 ton/ha to 9.0 ton/ha with an average of 6.5 ton/ha. The yields follow the rain patterns, with higher yields harvested from January to April and lower from August to December. The principle limitation factors in the rice cultivation in the highland jungle are infertile soils and pests (Alva 2000).

There are two ways of cultivating rice; direct with machinery or by hand using a wet-bed rice nursery so called almácigo. Almost 100% of the rice cultivations in San Martín are using the almácigo. In the almácigo seeds are distributed on a small surface in the field, and together with water they will germinate. Around 100 kg of seeds per ha is needed and after 30-35 days the rice plants are ready to be transplanted into the field (Photo 1). Pest control activities are also performed in the almácigo. The transplantation is made by day workers so called *peónes*. The most common type of rice cultivated in the Selva alta region is the *Capirona*. The water is lead out from the field around 20 days before harvest. After approximately 140 days the rice is ready for harvest, either by machinery or peónes. The field is left to dry for a week after harvest so that the land levelling machine (la niveladora), animals and the two wheels tractors (la rasta) will be able to pass the field without problem. Many farmers do also use a practise called *cabrilla*, where the rice plants are left after harvest and are allowed to grow again (Photo 2). If the farmer uses cabrilla they will have 3 harvests per year.

Photo 1. Rice plants in an almácigo ready to get transplanted   Source: Agneta Andersson

Photo 2. A rice field ready for cabrilla

Recent legislation (D.S. No 021-2005-AG NR) ratified in May 2005, prohibits the use of cabrilla irrespective of circumstances. The majority of the farmers in this study were not aware of this. The state also suggests a maximum area of rice cultivation to avoid price reductions (MINAG 2005). This number was exceeded on a national level with 50 000 ha in 2005-2006 when there were 349 859 ha of rice in Peru instead of the recommended 298 600.

The problems with pest in the jungle area due to its high humidity and temperature are well known. Because of the possibility year-round production and the lack of synchronization between the rice fields, it is difficult to break the life cycle of the insects, aggravating the pest problems. The insects can move from field to field without disturbance. According to Ing. Leiva at the Peruvian National Agrarian Health Service, SENASA, a project is planned in Tarapoto to synchronize the sowing and harvesting, as an attempt to decrease the pest outbreaks. After harvest, the rice is sold to a rice mill for further processing. The rice cultivated in the Tarapoto region is for local use and there has been a surplus in the production that had led to low prices and strikes.

2.4 Pesticides

According to the farmers in the study it is not possible to cultivate rice in the tropics without pesticides. Pesticides can be defined as a substance or mixture of substances that can be used for controlling, preventing, destroying, repelling or mitigating the effects of a pest. The Latin word *cida* means to cut or kill, and there are many types of pesticides available today for the control of unwanted organisms. Examples are insecticides, fungicides, herbicides, algaecides etc. Chemicals that do not actually kill pests may still, for practical and legal reasons, be considered pesticides. It also includes the chemicals used for disease vectors control. Twenty years ago it was regarded as positive if a pesticide was persistent, so that the effectiveness of the pesticide would last longer. Today the ideal is the opposite; the optimal pesticide should rapidly break down to harmless substances like carbon dioxide and water as soon as it has hit the target against which it was applied.

WHO has grouped the pesticides in different groups depending on their toxicity. The groups and the LD_{50} values are showed in Table 3.

Table 3. Classification of toxicity according to WHO (WHO 2004)

		LD_{50} for the rat (mg/kg body weight)			
Class		Oral		Dermal	
		Solids	Liquids	Solids	Liquids
Ia	Extremely hazardous	5 or less	20 or less	10 or less	40 or less
Ib	Highly hazardous	5-50	20-200	10-100	40-400
II	Moderately hazardous	50-500	200-2000	100-1000	400-4000
III	Slightly hazardous	Over 500	Over 2000	Over 1000	Over 4000
U	Unlikely to present any acute hazard in normal use	Over 2000	Over 3000	Over 4000	Over 6000

The hazard is the inherent potential of a substance to harm human beings or the environment. The hazard classification depends on the properties of a substance only. Important factors, among many, to consider about each pesticide are the toxicity, persistence, metabolites, and solubility in water and fat. The toxicity according to WHO is mainly based on the LD_{50} for rats. The LD_{50} value is a statistical estimate of the number of mg of toxicant per kg of bodyweight required to kill 50% of a large population of test animals. The WHO classification takes into account the acute risk to humans only, not other environmental risks. In addition to the WHO classification, SENASA in Peru in January each year publishes a list of which pesticides that are banned or restricted.

2.4.1 The trade of pesticides in Peru

SENASA registered 833 pesticides in Peru in January 2005. Of the pesticides used, 11% are classified as Ia or Ib, 87% of which are insecticides (Table 4). Although the percentage pesticides classified as Ia or Ib is "small", the use of them is significant. Methamidophos, with commercial names like Tamaron, S-kemata, Stermin, Monitor, was the most imported pesticide 1999-2000.

Table 4. Some information about the trade of pesticides in Peru

<table>
<tr><td>Classification according to WHO</td><td>Colour of label</td><td>Number of pesticides registered in Peru 2005</td><td>% of the total</td></tr>
<tr><td>Ia Extremely hazardous</td><td>Red</td><td>10</td><td>1.2</td></tr>
<tr><td>Ib Highly hazardous</td><td>Red</td><td>85</td><td>10.1</td></tr>
<tr><td>II Moderate hazardous</td><td>Yellow</td><td rowspan="2">738</td><td rowspan="2">88.7</td></tr>
<tr><td>III Slightly hazardous</td><td>Blue</td></tr>
<tr><td></td><td></td><td>Total 833</td><td>100</td></tr>
</table>

Source: Listado de Plaguicidas Agrícolas Registrados en el SENASA (Enero 2005), but compiled by RAAA (RAAA Marzo 2006)

It is often stated that pest control increases the agricultural yield. A study made by the Peruvian network RAAA (Action network for alternative agriculture) shows no direct relationship between the agricultural production and the use of pesticides in Peru (Figure 3). RAAA is working for a sustainable agriculture and conservation of the environment. The pesticide issue is an important factor in their work and they are now working to decrease the use of extremely and highly hazardous pesticides and to implement better legal regulations in Peru (Aldana et al. 2002).

After the tragedy in Tauccamarca, legislation became more restrictive and several of the very toxic pesticides were banned in 1999. The labelling was also questioned. Before a pesticide is released on the marked the labelling must be standardized and approved by SENASA.

In Sweden taxes are implemented to cover a part of the cost of the pesticide contamination. In many developing countries the scenario is the opposite. The governments often subsidize the agriculture to increase the food production to reduce poverty.

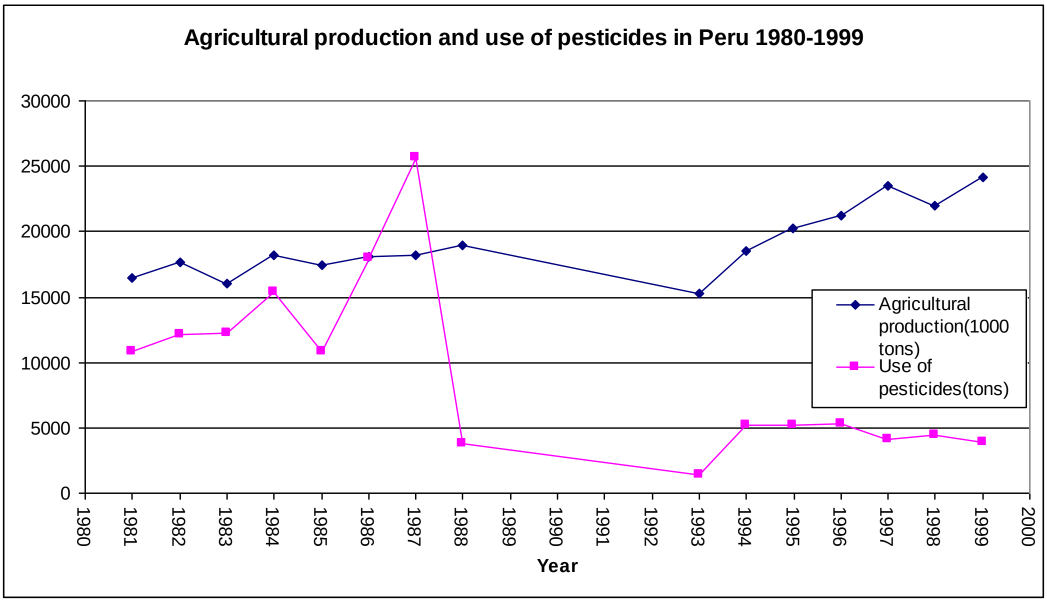


Figure 3. Agricultural production versus use of pesticides (RAAA Setiembre 2006)

2.4.2 The trade of pesticides in Tarapoto

In Tarapoto most of the pesticides are sold in centre of the town along Raymondi Street (Photo 3). The pesticides are sold in so called agro-stores, where often also veterinary supplies are found. There are around 15 agro-stores along Raymondi Street together with other commercial activities like restaurants and Internet cafés. The smell of agrochemicals along the street is strong. The salesmen in the agro-stores are a mix of professionals and persons without higher education. The agro-stores must have at least one professional engineer to bee registered by SENASA; a legal requirement under Peruvian law. The salesmen in the stores often visit the farmers in the field and suggest what kind of pesticide they should use. Theoretically the salesmen are responsible for the yield and they often recommend the most expensive and toxic pesticides to be sure that the pest disappear. They also get a commission of around 5% of what they sell. SENASA is the control organ for the use and trade of the agrochemicals and make constantly visits to the agro-stores. According to Ing. Sixto at the SENASA office in Tarapoto, the main problem for SENASA at present is not the use of banned pesticides but the pesticides that are smuggled across the borders. These pesticides are often found in bottles with larger volumes. In addition, old names of pesticides are “still going strong” as many farmers connect these names with something positive. For example, a container that contains a newer compound can be labelled with the name of an older well known, but banned, compound (Photo 4). During the study, we never observed active use of banned pesticides.

Photo 3. Pesticide advertisements in the street of Raymondi, Tarapopto

Photo 4. An illegal product confiscated by SENASA. It is labelled with DDT but the content is a pyretroid

2.4.3 The use of pesticides in the study area

In Tarapoto, the economic situation of the farmers influences decisions on pest management. Laws and regulations also play a role. The prohibition of various pesticides during the late 90´s seems to have succeeded and there were no signs of use of organochlorine pesticides.

According to the Regional director at SENASA, the typical rice farmer in the region is a person from a poorer part of the country that has sold everything and comes to Tarapoto to grow rice, knowing neither the cultivation process, nor the appropriate and safe use of pesticides. For many farmers, the salesmen in the agro-stores are the only source of information about pesticides, and this in part explains why they have such major influence of the use of pesticides in the region. Many of the pesticides sold according to WHO classification are highly hazardous. Most of the farmers in the study area seemed to spray their fields by themselves or together with a *peón* or a family member. No woman was observed with a backpack sprayer, but they helped out mixing the pesticides next to the field. The constant spraying cause pest resistance to particular chemicals and probably has led to overdosing in the rice fields. According to Ing. Chappa, the dosage on the rice fields can be up to 8 times de recommended (Chappa 2005). The use of broad-spectrum pesticides has also lead to a loss of natural enemies to the pests.

Not only are the pesticides themselves a problem, but also the plastic containers, bottles, cans, and vessels that contain the chemicals. An estimate is that ten plastic bottles are used per harvest season and ha. If every bottle weight 80-100 g (Díaz 2002), the pesticides used on the 456 ha of rice fields irrigated by the Cumbaza River in the study site results in 1.0-1.3 tonnes of plastic garbage every year. Today there is no easy solution to the safe handling of the empty pesticide bottles (Photo 6).
The people working on the fields do not, in general, use adequate protective gear. According to the study by Agneta Anderson, the reasons are neither lack of

information nor inability to read the labelling, but the hot climate, laziness, machismo, and bad habits (Andersson 2005). The farmers included in this study do not reflect the education level and knowledge among farmers in other parts of the country. For example, the grade of protection did not correlate with the educational level and economy, which is contrary to other studies from Peru (RAAA Setiembre 2006). The problem of wearing additional protective equipment in tropical countries is a well-known fact and has been commented on several times over the years. In 1984 the FAO Group of experts on Pesticide Registration Requirements recommended the preparation of a FAO guideline on protective clothing suitable for use in the tropics (FAO 1990).

In addition to the problems with personal protection during spraying, cleaning the spraying equipment is also a problem. Due to limited washing possibilities, the spraying equipment is washed in irrigation canals or in the small streams that reach the Cumbaza River. The same river where a lot of people fish, wash their clothes and from where some populations downstream take their drinking water.

Photo 5. Mixing of pesticides and filling of backpack sprayers before spraying
Source: Agneta Andersson

Photo 6. A collection of empty pesticides bottles next to a field

2.4.4 Effects of the use for human and environment

A pesticide can enter a human via oral or dermal uptake, or inhalation. Exposure to pesticides can cause both short-term and chronic health effects. Short-term effects can include headaches, eye and skin irritation, diarrhea, faintness, vomiting, labored breathing, coma, and even death. Chronic health effects can occur after exposure of pesticides, even in small doses under a long time. Symptoms can be neurological disorders, reproductive failure, endocrine disruption, chronic cough, cancer etc. Children are especially vulnerable to toxic substances. It is common to bring the children to the field and sometimes they also spray or mix the agrochemicals (Photo 7 and 8). Accidents have occurred in the area when children have drunken agrochemicals by mistake.

Photo 7. A young boy is helping his father spray the field
Source: Agneta Andersson

Photo 8. A small girl sitting next to a field waiting for her father

In the small health care centre of Morales four cases of intoxications due to pesticides were reported from January to July 2005. Two occurred while spraying while the other two were suicide attempts. Intoxications due to pesticides decrease drastically between 2001 and 2002 (Table 5) and there not seem to be any clear explanation for this. It must be noted that the statistics only cover cases reported from the healthcare centres and may be far from the real numbers. Suicide cases are also included in these numbers. The numbers of intoxications increased with 52.5% in the department San Martín between 2003 and 2004.

Table 5. Intoxications due to pesticides registered from healthcare centers and hospitals in the Tarapoto region and in the whole department San Martín

	2001	2002	2003	2004
Tarapoto, Morales, La banda de Shilcayo, Cacatachi	77	23	23	29
Entire department San Martín	190	96	78	119

Source: Ministerio de Salud, Tarapoto 2005

Water supplies contaminated with pesticides do not only impact the safety of drinking water, but may also affect aquatic life, birds, and other animals that depend on these water sources. Many insecticides and some fungicides have effects on invertebrates that may be of importance for biological control of pest attacks. The nature of the damage is seldom known, why it is difficult to connect exposure and effects, especially in a long-term perspective. Certain insecticides, i.e., organic phosphorus compounds and pyrethroids, cause great damage to honeybees, bumblebees, and other pollinating insects. The ecological effects of herbicides are probably more important for the insects than direct acute toxic effects (Torstensson 1989). The great changes in the landscape through deforestation and the introduction of monoculture in the study area may also have had a great negative effect on the diversity of flora and fauna. Surprisingly, amphibians, both tadpoles and adult frogs, were observed in drainage ditches and on fields in the study site.

Lack of research on pesticides in the tropics makes it hard to estimate the fate of the pesticides in the environment. For example in a 10-year period, literature citations on research in tropical soils compared to temperate soils were in the ratio 1:3 (Carazo 2002). Most of the pesticides are not even tested on tropical organism or in tropical ecosystems.

2.5 Probable transportation and losses of pesticides in the study area

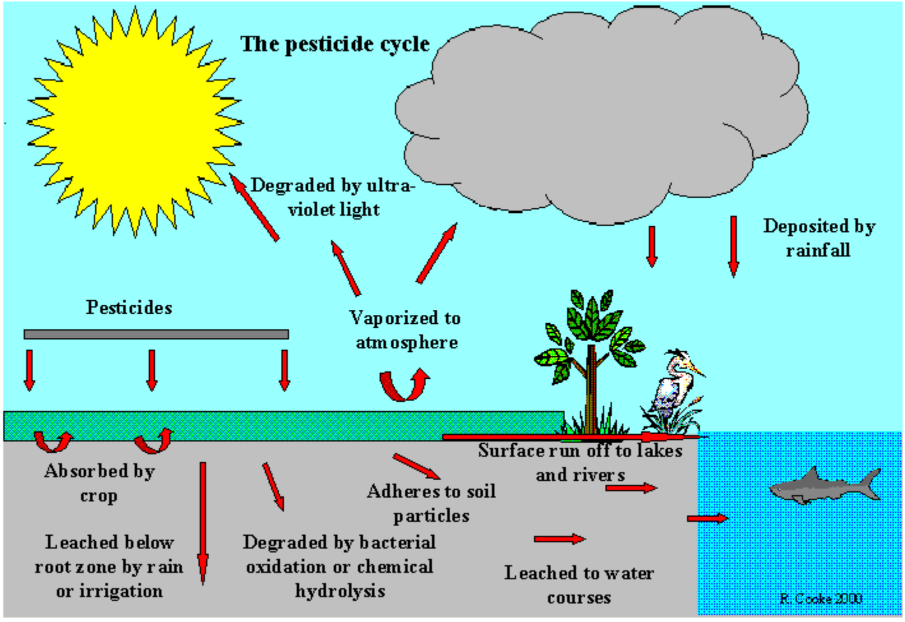


Figure 4. Possible pathways in which the pesticides can reach surface- and groundwater (ECIFM 2007-05-15)

Pesticides may dissipate by many different routes in the environment (Figure 4), and may reach the water through diffuse pollution or point sources. The diffuse pollution is for example volatilization, precipitation, run-off, leaching, and also the general spraying of diluted pesticides. The spraying can be both intentionally (e.g., control of waterweeds) or unintentionally (e.g., wind drift from fields next to a stream).

The point sources are from chemical spill, for example when sprayers are loaded, faulty equipment, washings or when pesticides are mixed. Spill with 1 g of an active substance on a surface of 1 dm^2 is the same concentration as to spray 1 ton of the active substance on one ha.

Water pollution all over the world is getting more complex as additional kinds of pesticides are manufactured and larger amounts are used. There are also problems to analyse pesticides and especially in the developing world where laboratory equipment and resources are limited. It is difficult to isolate specific pesticides from the great amount of other chemicals in the water and the analyses are complex and very expensive.

Pesticides generally move from fields to surface water via surface run-off or in drainage, induced by rain or irrigation. In this study the water is routed from the rice fields to drainage ditches, to small streams that finally end up in the Cumbaza River. Pesticides can leave the fields either as a dissolved substance or associated with soil particles. In which form the pesticide are transported from the field depends largely on the properties of the compound. Most pesticides found in run-off from fields are in the dissolved form. Exceptions are compounds with a very low water solubility (less than 1mg/l) or strong ion-exchange with clay minerals (Wauchope 1978). The most common way of pesticide transport in the soil is through the movement of water. Usually the transport is downwards in the soil profile, but there are also horizontal movements of water (Torstensson 1989).

When the pesticides have been spread there are a few biological-, physiological- and chemical processes that can prevent or speed up the transport of the pesticides in the area.
Five factors that regulate the degradation and the transport of the pesticides in run-off water are as follows:

1. Climate factors
2. The characteristics of the pesticide
3. The properties of the soil
4. The topography
5. The agricultural practices

2.5.1 Climate factors

The amount, intensity and duration of the rainfall are climate factors that affect the transport and the degradation of pesticides. The time with respect to the application also affect the fate of the compounds. Seasonal variations and changed weather conditions can have a major influence of the concentrations of pesticides in water.

Other climate factors that regulate the degradation of the compounds are the temperature and radiation. The high temperature with small changes during the year in the tropics, compared to temperate areas will increase the biological activity and increase the degradation rate of pesticides significantly (Carazo 2002). The mean daily sun radiation reaching the tropics is twice that received in temperate zones.

2.5.2 Characteristics of the pesticide

Each pesticide has a unique set of properties, which defines the pathways that the pesticide can enter the environment. Characteristics like water solubility, the adsorption constant, half-life and vapour pressure are important. The presence of certain functional groups such as -OH, $-NH_2$, -NHR, $-CONH_2$, -COOR, and $-^{+}NR_3$, in the structure of the pesticide facilitate adsorption, especially on the soil humus (Brady & Weil 1999).

2.5.3 The properties of the soil

Soil properties that, among others, influence the transport of pesticides are structure, texture, amount of organic material or clay minerals etc. These factors will affect both the soils ability to retain water and the degradation. Sandy soils retain less water than clay or organic soils. The heavier the soil is the lower is the potential for leaching.

Subtropical and tropical soils differ from temperate soils mainly in the quality of clay minerals and in the amount of iron oxides and organic matter. Some characteristics of a tropical soil among others are very high weathering rate, low nutrient content and a tropical soil also often has a good structure with macro pores (Brady & Weil 1999). The pesticides can due to the macro pores be transported easily through the profile by rain, and the groundwater can be in the risk zone to be contaminated.

2.5.4 Topography

The topography is a factor that influences the transportation of run-off water. The risk of surface run-off of pesticides increases with increasing slope. Residues may accumulate in depressions. The distance to the water table also influences the risk.

2.5.5 Agricultural practices

The agricultural practices play a big part in the spread of pesticides, and especially the application methods and the handling of the chemicals. The tillage methods and the presence of buffer strips do also have an impact. The pesticides may also dissipate from point sources like washing of sprayers.

2.6 Parameters of pesticides that influence processes in the soil

2.6.1 Degradation

Factors and processes that affect the degradation of pesticides in the soil are:

- Half-life, DT_{50}
- Biodegradation
- Photolysis
- Hydrolysis

The degradation is measured by the *half-life, DT_{50}*. It is a measure of the amount of time it takes for 50% of the original quantity of an active ingredient applied to disappear from soil or water by transformation. Compounds with an extremely long degradation time, such as the first generation organochlorine pesticides, are considered persistent. In general, modern pesticides have a shorter half-life and are more specific so that a lower amount of the chemical can, and should be used. The half-life for the modern pesticides can vary from a few days to more than a year. The variation depends not only on the properties of the pesticide, but other factors mentioned like temperature, humidity etc. Most pesticides degrade over time as a result of several chemical and microbiological reactions in soils. The important degradation processes are biological processes as biodegradation, and physicochemical processes like hydrolysis and photolysis (FAO 2000).

Biodegradation is the transformation of a compound by organisms, chiefly by micro-organisms. The activity of the micro-organisms is affected by various factors like temperature, humidity, salinity and the presence of oxygen and nutrients etc.

Photolysis is the break down of substances by sunlight. Direct photolysis is the result of absorption of sunlight by a pesticide, causing a chemical transformation like cleavage of bonds, oxidation, hydrolysis, rearrangement etc (Larson et al.).

During *hydrolysis* is compounds split by contact with water. This reaction is strongly dependent by the pH of the environment, and the process is important for many organophosphorus and carbamates.

The final products in most of the reactions are the mineral compounds of CO_2, H_2O, HCl, SO_2, etc. As the products are breaking down, some pesticides produce intermediate substances (metabolites) that also affect the environment. These forms of the compound can be even more dangerous than the original one.

Table 6. Classification of degradability in soil (FAO 2000)

DT_{50} (days)	Classification
<20	Readily degradable
20-60	Fairly degradable
60-180	Slightly degradable
>180	Very slightly degradable

2.6.2 Mobility

The mobility of a pesticide can be described by the parameters:

- Water solubility
- Soil-water partition coefficient K_{oc}

The *water solubility* of a compound is given in mg/l at 20 °C. Substances with high solubility can move quickly in to water systems and can be expected to leach into groundwater. The water solubility of a pesticide can also indicate the maximum amount of pesticide in solution in any accidentally contaminated water.

Table 7. Classification of solubility in water (FAO 2000)

Water solubility (mg/l at 20 ^{0}C)	Classification
< 0.10	Not soluble
0.1-1	Slightly soluble
1-10	Moderate soluble
10-100	Readily soluble
>100	Highly soluble

The *partition coefficient* K_{oc} is defined as the ratio of pesticides concentration in a state of sorption (i.e., adhered to soil particles) and the solution phase (i.e., dissolved in the soil water). The smaller the K_{oc}, the greater the concentration of the pesticide in the solution phase. Therefore, a pesticide with a small K_{oc} has a greater tendency to leach into groundwater. On the other hand, pesticides with high adsorption (high K_{oc})

in soil are tightly bound to soil particles and less likely to move into water systems. Sorption for a given pesticide is greater in soils with a high content of organic material, why the risk for pesticide leaching is lower in organic soils than in mineral soils. Most of the modern pesticides do not absorb to the soil as strong as the older ones. Therefore older types of pesticides are more often found in sediment while modern types are dissolved in the water. With an increasing mobility, the risk to find the modern pesticides in groundwater and watercourses should also increase. Once pesticides reach the groundwater they are usually degraded very slowly. They may spread further via the groundwater and they may reach wells for drinking water.

Table 8. Classification of mobility (FAO 2000)

Log K_{oc}	Classification
<1	Highly mobile
1-2	Mobile
2-3	Moderately mobile
3-4	Slightly mobile
4-5	Hardly mobile
>5	Immobile

2.6.3 Bioaccumulation

Bioaccumulation is the tendency for a compound to accumulate in organism from the surrounding medium. A pesticide that is lipid soluble can accumulate in body tissues and are usually found in organs with high fat content. The risk of bioaccumulation in organisms is measured by the partition coefficient K_{ow}, which is defined as the concentration of a compound in *n*-octanol divided by the concentration of the same compound in water. A high K_{ow} value leads to a low solubility in water and a higher tendency to accumulate in organisms (FAO 2000). A log K_{ow} value >3 indicates a propensity to bioaccumulate. The half-life of the substance is another important factor that influence if there will be an accumulation or not. This includes both the abiotic half-life in, e.g., water, and the rate of metabolism in the specific organism.

3. Material and methods

This report is one part of three in an interdisciplinary study. The other parts were done by Agneta Andersson who investigated the distributors' role in the usage of pesticides, and Gun Lange who analysed blood samples to evaluate impacts of pesticides on the rice farmers health.

This part of the study focuses on the water sources found throughout the study area. The research methods can be divided in two parts; semi-structured interviews and water sampling.

3.1 Semi-structured interviews with PRA/RRA tools

The first contact with rice farmers took place on May 26, 2005, at one of the roadblocks that disrupted the traffic for 10 days between San Martín and the rest of the country. The farmers protested against the low price on rice, more expensive pesticides and fertilizer etc. According to the farmers, one of the reasons for the low rice price was the import of rice from other parts of the world. This roadblock did not improve the situation for the farmers. At the roadblock, contact was made with rice farmers and the president of the irrigation committee of Rosanayco. After a meeting in the committee, seven voluntary rice farmers were chosen and contacted randomly for further collaboration.

Semi-structured interviews with PRA/RRA tools took place with the voluntary farmers. The methods used by PRA/RRA and their purposes are given in Table 9. The interviews took all place without an interpreter due to fluency in Spanish, and usually in the field of the farmer to facilitate the understanding of the farming conditions. The water samples were collected at the same time as the interviews. The key questions in the interviews were; why, where, when, by whom and how (Appendix I and II). The qualitative data gathered from the PRA/RRA interviews were analysed and appropriate sampling sites were chosen.

Photo 9. At the roadblock May 26 2005, contacts with rice farmers were established

Photo 10. A part of the semi-structured interview with a rice farmer in the field Source: Gun Lange

The interviews also helped us to understand the socio-economic condition, rice cultivation practises, and to probe and evaluate the local knowledge about pesticides. The drinking and eating habits of the farmers were also surveyed. Observations were made to study the use of the pesticides, spraying equipment, the packaging, storing, labelling, security instructions, and trade. Contacts with relevant agro-stores were also established to gather information about their marketing strategies, trade and sales volumes.

Table 9. Purpose and description of different PRA/RRA-tools that were used (Fagerström et al. China (1997-2000) and Vietnam (2001-2004)

Tool	Level	Purpose of tool/Information
Day clock	Farm	Labour division for men and women, drinking and eating habits etc
Time line	Village (farm)	Infrastructure, economical reforms, land division, prices and amount of pesticides used etc
Seasonal calendar	Farm	Labour and their division during the year, seeding, harvest, spraying, climate, etc
Sketch map	Farm and village	Relative location of the farm and village, roads, paths, the distribution of houses, cropland and other land, water resources, landscape characteristics in relation to land use, land ownership etc

3.2 Water sampling

Twenty-four water samples were collected in 2-litre glass containers from different water sources related to rice fields in the districts Morales and Cacatachi close to the city of Tarapoto. The containers were washed with ethanol (95%) before and after the sampling. The samples were taken from 2 June to 2 of August 2005 and were distributed in the following way: 12 irrigation canals, 5 surface water, 3 ground water, 3 from water in rice fields and 1 from water in a rice nursery (almácigo).

Table 10. The distribution of the samples in the study

Water source	*No of samples*
Irrigation canals	12
Surface water	5
Ground water	3
Field water	3
Rice nursery (almácigo)	1
Total	**24**

A pressure filtration apparatus was brought from Sweden to Peru to extract the pesticides from the water with a technique developed for this type of work (Moraes et al. 2003).

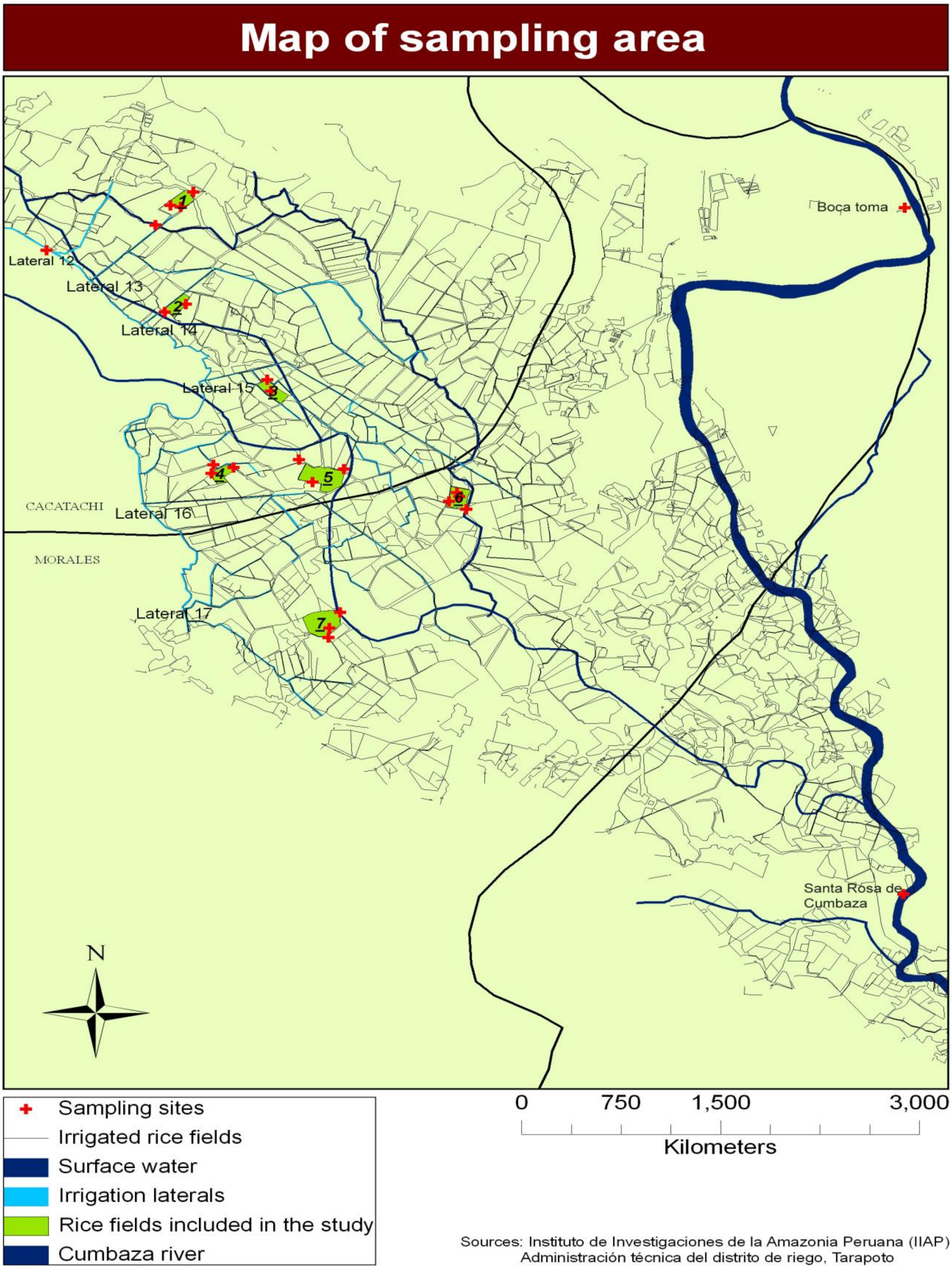
Each sample was divided into two phases; a particulate and a dissolved phase. The particulate phase consists of pesticides bound to particle, which are collected on a filter. Pesticides in the dissolved phase are collected on a Solid-Phase Extraction (SPE) cartridge. The SPE-cartridge contains a sorbent having high affinity for non-polar pesticides, in this investigation a styrene-divinyl copolymer ENV+ (International Sorbent Technology, Hengoed, Mid Glamorgan, UK) was used. Water and other polar substances pass through the cartridge unretained, whereas the organic compounds, in these case pesticides, are retained by the sorbent.

Eleven of the SPE-cartridges were pre-washed with dichloromethane (2 x 5 ml), methanol (5 ml) and deionised water and then wrapped in aluminium foil in Sweden. SPE-cartridges numbers 12 to 24 were pre-washed in the laboratory of phytopathology at the National University of San Martín in Tarapoto. The aim of the pre-washing is to remove as much interferences as possible that can hamper the subsequent quantification.

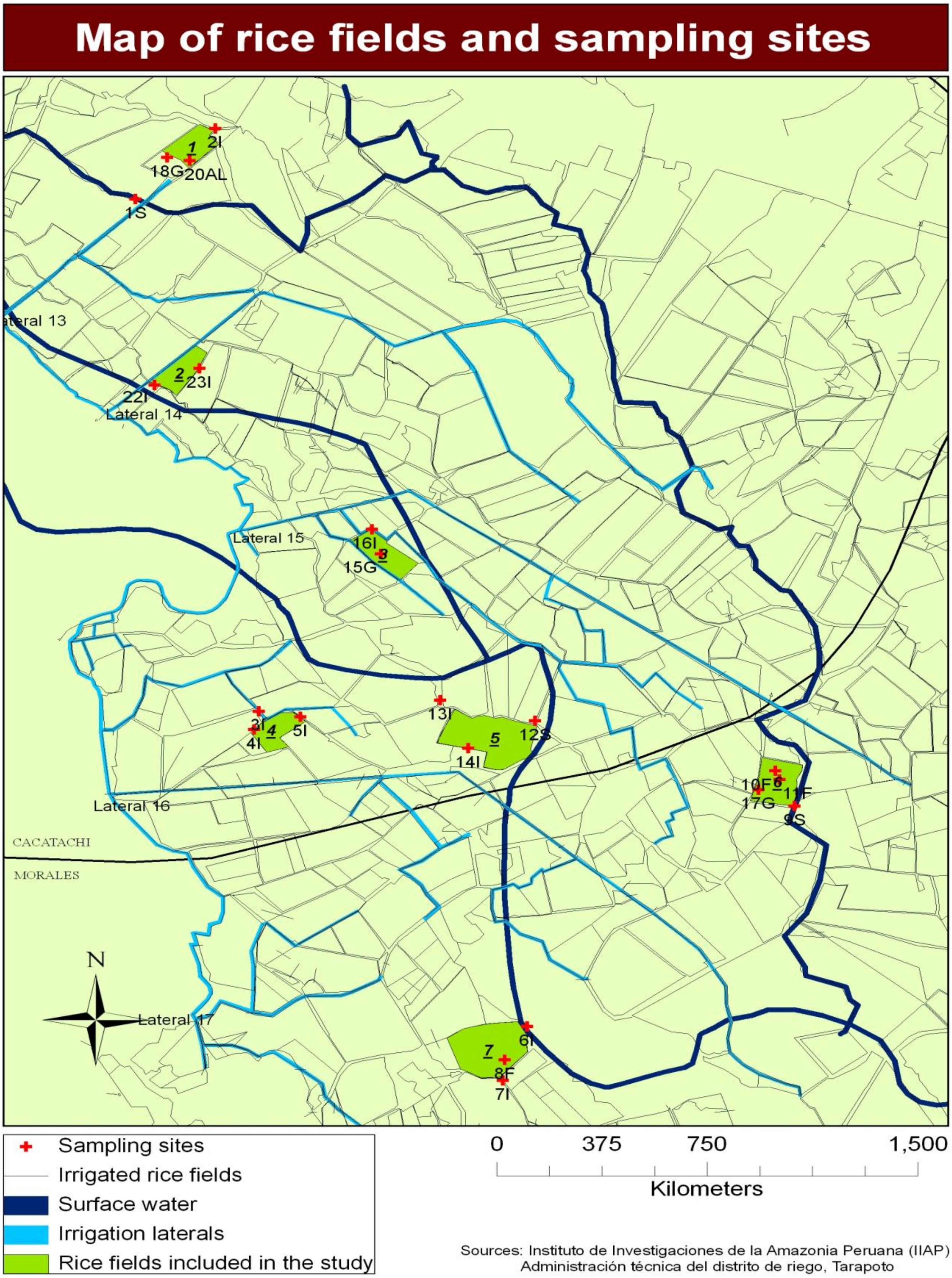
After that the water has passed through the extraction setup the used filter/s were carefully folded with a flat forceps and put into the respective SPE-cartridge. A few drops of dichloromethane were added on the filter in the cartridge to avoid further contamination. The SPE-cartridges with the filters were wrapped in aluminium foil and kept as cool as possible during the whole time, and were brought to Sweden for further processing. All water samples were extracted on the sampling day except sample number 20 that was kept in a refrigerator over night and extracted the following day. For security reasons the chemicals used in Peru were not stored in a refrigerator.

Photo 11. The SPE-technique. The water sample is forced through the SPE-cartridges with air pressure. The pressure is created in the sampling vessel with a bicycle pump due to vacuum in the vacuum chamber. First the water passes through a filter (Whatman GFF glass microfibre, 47 mm diameter) that collects the particles in the sample and then through the cartridges. If needed, the filter can be changed. The water that passes through the cartridge is then collected and the volume measured (Kylin 2007).

3.2.1 The rice fields and sampling sites



Map 2. Net of irrigated fields in the study area with all the sample sites included



Map 3. The rice fields and sampling sites connected to fields, I=irrigation canals, S=surface water, G=ground water, F=field water (Al=almácigo)

Table 11. Information about the rice fields in the study

Field number	1	2	3	4	5	6	7
Area (ha)	1.5	1.5	2	2	5	2.5	4
Soil moisture	Dry	Dry	Dry	Humid	Dry	Wet	Humid
Dates of sampling	2005-06-02 2005-07-27	2005-08-02	2005-07-13 2005-07-14	2005-06-03	2005-06-16	2005-06-14 2005-07-23	2005-06-10
Depth of ground-water	70 cm	Unknown	70 cm and 100 cm	Unknown	Unknown	130 cm	Unknown
Rice type	Capirona	Capirona	Selva baja	Capirona	Capirona	Capirona	Capirona
Rice age	45 days after harvest (16/4-05) *Almácigo* 22 days (6 days before transplantation)	165 days (13 days before harvest)	8 days after harvest (5/7-05)	45 days	30 days after harvest (17/5-05)	100 days and 137 days	55 days
Irrigation water from latoral	13	14	15	16	16	15	16
Dates of last rains before sampling (mm)	1/6 (4 mm) 26/7 (5 mm) 18/7 (18 mm)	26/7 (5 mm) 18/7 (18 m)	14/6 (14.5 mm) 7/7 (9.4 mm)	1/6 (4 mm)	15/6 (0.4 mm) 14/6 (14.5 mm)	14/6 (14.5 mm) 11/6 (1 mm) 18/7 (18 mm)	5/6 (6.4 mm)

Field number	1	2	3	4	5	6	7
No of pesticide applications/ Harvest	6	8-10	8-14	10-12	6-8	8-12	6-8
No of days since last application/s and active ingredients	75- (19/3-05) endosulfan and glyphosate *Almácigo* 2- (25/7-05) and 7- (18/7-05) cypermethrin 10- (17/7-05) glyphosate around borders	7- (26/7-05) cypermethrin and 4 kg of other substances from Quimica Suissa	33- (18/7-05) methamidophos and cypermethrin	8- (26/5-05) Carbofuran and propineb The same day- bispyribac-sodium	7-(9/6-05) Butachlor and probably around 2 month ago with an insecticides containing carbofuran, imidacloprid or cypermethrin	the same day- methamidophos, alpha-cypermethrin, carbendazim/ benzamidazole and tebuconazole 25-(20/5-05) carbosulfan, carbendazim/ benzamidazole 50-(25/4-05) endosulfan, imidacloprid propineb *Ground-water* 22-(1/7-05) methamidophos, propineb	3- (7/6-05) metsulforon 8-(2/6-05) endosulfan

3.2.*2* Water from irrigation canals

One sample was collected from the principle irrigation canal (Canal madre) just upstream of the lateral irrigation canal number 12. The other 11 samples were taken from irrigation ditches connected to the lateral irrigation canals number 13 to 16. The flow in the canals varied from stationary, to fast flowing water. There was a lack of water during the sampling period due to the re-construction of the principle canal.

Photo 12. A great flow of water in an irrigation canal connected to field 3

Photo 13. Muddy stationary water in an irrigation canal connected to field 7

3.2.3 Surface water

Surface water samples were collected in the small streams of Huascachaca, Mishquiyacu and Codo seco, which all are connected to rice fields. Two samples were collected from the River Cumbaza; one before the principle irrigation canal starts (Boca toma) and one after the discharge of water from the rice fields in the study area into the river (Santa Rosa de Cumbaza).

Photo 14. River Cumabaza at the Boca toma before the principle irrigation canal starts

Photo 15. River Cumbaza at Santa Rosa de Cumbaza

3.2.4 Groundwater

Three groundwater samples were collected from holes dug in the ground. One of the three samples was a composite sample collected from two different holes at rice field number 3. The sampling sites were close to the irrigation laterals 13 and 15, and the depth from the surface level varied between 70 and 130cm.

Photo 16. Sampling of ground water next to Field 1 (Gun Lange)

Photo 17. Ground water at Field 3

3.2.5 Water from fields

Four samples were collected directly from fields, one of which was from a plant nursery. The water levels on the fields varied from 2-20 cm. Samples 10 and 11 are collected from the same field before respective after rain and spraying. All were composite samples.

4. Analyses

Instrumental analyses were performed at the Department of Environmental Assessment at SLU, Uppsala with some assistance of the co-workers at the laboratory. Methamidophos, carbofuran and carbosulfan were analysed at the Norwegian Institute for Air Research (NILU), Tromsø, Norway.
Different extraction and cleaning steps were adjusted to the specific type of sample analysed.

The water and the filter samples were qualitatively and quantitatively analysed for pesticides on GC-ECD. Some of the filters were pooled together in the analyses. Standard solutions were used to detect 23 different pesticides/metabolites and to calculate their concentrations. A recovery study was done with water from River Kolbäcksån and River Lenakyrkaå to verify the validity of the method (Appendix XVI). No recovery study was made for the filters. Procedures during the extraction and the analyses, and the pesticides/metabolites included are presented in Appendix XV. Blanks of the SPE-cartridges, filters and recovery samples were extracted and analysed in the same way as the ordinary samples.

5. Results

5.1 Outcome from the interviews and own observations

The deep interviews gave important information about the living conditions and the agricultural practices at the study site. Despite the small number of interviewed farmers, their answers seem to reflect the situation for many of the rice farmers in the region.

All rice farmers in the region use pesticides. The doses and brands vary between the farmers and also the number of applications. All are small-scale farmers usually with less than 5 ha of rice fields. The seven farmers, who volunteered for interviews, all handled pesticides in a similar way. None of them used pesticides or fertilizers when they started to cultivate rice, as there was no need at that time. The common opinion is that the number of pests is increasing continuously and with this also the pesticide doses and number of applications accompanied by decreasing yields. An inventory made during this study showed that the farmers used 61 pesticide formulations with 31 active ingredients (Appendix IV).

Appendix V shows the commercial name and the respective active ingredient used on the different fields included in the study. The pesticides are mixed, and the motor driven backpack sprayers charged in the field. The different PRA/RRA tools used during the interviews were a good help to get a deeper understanding of the life of a rice farmer. The *Sketch map* gave a good overview of the location of the field, water resources, distributions of houses, roads etc. The *Time line* showed the personal history of each farmer and also important events that had occurred in the region. Integrated cultivation systems with crops like, e.g., plantain, cassava, corn, beans, sunflowers, and fruit trees were changed to monocultures of rice. The same scenario occurred in other parts of San Martín. Some of the farmers took loans from rural banks to be able to start the cultivation of rice, while others had the possibility to invest with their own savings. The answers from the S*easonal calendar* varied. There were different opinions which months that had the highest precipitation or the highest abundance of pests. This is an indicative of the unpredictable climate in the region. During years with the climate phenomenon *El Niño*, Tarapoto is severely affected. During 2001 the flow in River Cumbaza reached a maximum of 952 m^3/s in May at the hydrological station at the Boca toma. This can be compared with a normal year with a flow around 50 m^3/s during the same month. The high flow in Cumbaza River led to that 300 ha of agriculture land were inundated in the catchment area, many people lost their homes and there was a loss of 170 000 Euro (ATDR 2006). Another effect caused by *El Niño* in 2001 was a harsh drought (sequía) in the north of the country. This lead to big losses of rice yields in this part of the country and better price for the rice farmers in the San Martín region. The rice farmers in Tarapoto talked about the year 2001 as a good year when their economy prospered. *El Niño*-years seem to become more frequent. Many persons in Tarapoto blame the “extreme” climate on the deforestation of the mountains. The answers from the season calendar do also indicate that there are problems with the synchronization of the rice cultivation among the farmers. The months with pesticide spraying, sowing, and harvesting varied between the farmers. According to the *Day clock* and our own observations, is almost all the spraying done during the morning hours, i.e., before noon. The explanation to this is that both the wind and the heat increase during the day. Most of the interviewed farmers did not bring anything to eat to the field, but one of them had a breakfast break during the spraying. All the questions from the semi-structured interviews and examples from the PRA/RRA tools are showed in Appendix I, II and III. Some of the answers from the interviews are shown in Table 12.

Table 12. Some results from the semi-structured interviews

Question	Yes	Total # of answers
Immigrant to the area	3	7
Lives on the rice field	1	7
Stores the pesticides in the house	6	7
Spray or mix the pesticides	7	7
Use of recommended protective equipment	0	7
Always reads the label	5	7
Participates in seminars	4	7
Symptoms of intoxication due to pesticides	5	7
Washes the backpack sprayer in the irrigation canal	7	7

Three of the seven interviewed farmers have moved to Tarapoto from other regions. One reason to move was the dangerous situation due to terrorism in other parts of San Martín. The other four rice farmers changed their crops to rice when the irrigation canal of Cumbaza was constructed. Only one of the farmers lived on the field, the others were living in Morales or Tarapoto. The storing of the agrochemicals and backpack sprayers in this study was far from satisfied in many cases. Almost everyone stored their pesticides in their house. For example spraying equipment was observed in living rooms and even in a kitchen. Only one of the interviewed farmers stored the pesticides in a shed in the garden. Most of the farmers always read the label before spraying, but the understanding of the toxicity and the colour codes was limited. No one used protective equipment required on the labels of the pesticide bottles. None of the farmers were wearing any footwear or facemask during spraying, but covered their face with a piece of cloth. Both long legged and short legged trousers were used, and to some extent sweaters with long sleeves. The main reason to not use protective clothing is the hot climate. There were also other explanations like that they have been spraying for such a long time that they have become resistant to the chemicals, the cost, and that a strong man should be able to handle it. All farmers understood it was dangerous to spray without protective equipment, but did not seem to pay to much attention to this. This can be compared to smoking habits. People that smoke are aware of the negative effects on their health, but continue smoking anyway. The pesticides were also referred as medicine for the plants. Four of the farmers have participated together with the irrigation committee on seminars concerning the use of pesticides. Some seminars seemed to be organised by agro-stores probably with the purpose to sell their products. The most common symptoms due to intoxication were dizziness, skin irritation, nausea, diarrhoea, and vomiting. Other symptoms experienced by the farmers but not included in the questionnaire were nose bleeding, fainting, and body pains. Instead of visiting any of the hospitals or healthcare centres when feeling symptoms of pesticide intoxication, the farmers have their own recovery methods. All farmers drank milk, lemonade with sugar, or soda before and after the spraying to prevent intoxication. The farmers drink milk despite of the warning text on the label of some pesticide bottles containing, e.g., methamidophos. The consumption of milk, alcohol and oil before and after spraying with methamidophos can lead to a more severe intoxication. The salesmen recommend drinking milk, but most of them do not seem to know why. This is serious since the salesmen are the primary source of information about the use and handling of pesticides. All farmers wash their backpack sprayer in an irrigation canal or stream after use. Three of the seven rice farmers personally wash their clothes in the irrigation canal, while four of them bring the clothes home for their wives to wash them. An incident was reported when one of the wives was pregnant and washing the farmers clothes. The baby was born with signs of peeled skin around and in the mouth, and with very dry skin. The physician told the farmer that pesticide in the clothes could be an explanation for the baby's symptoms. Five of the interview farmers burnt the empty bottles, one brought them home and threw them in the garbage, and one left them in the field. Other important information was that all the farmers have observed a decreasing number of animals like snakes and foxes close to and along the fields.

As shown in Appendix V, many pesticides used on the fields were not included among the compounds quantified in the analyses. Unfortunately, no fungicide and only one herbicide were possible to include in the screening. The active ingredients imidacloprid, glyphosate, propineb, byspyribac sodium, isoprothiolane, tebuconazole, dimetilanimade-2,4, mancozeb, and tebucanzole are widely used in the study area, but could not be included in the screening as they would have required other methods of analysis. According to my own observations and the other reports in this project, the most commonly used pesticides are *Tamaron* and *Thiodan* with the active substances methamidophos and endosulfan respectively. Both these products were classified due to Resolución Directoral N^{o} 019-2005-AG-SENASA-DGSV in Peru as Extremely and Highly Toxic, respectively. In December 2005 the classification system was changed which led to a less strict classification of toxicity in Peru, more in line with the WHO-classification.

The active substance of metamidophos is restricted in Peru (SENASA 2007). This means that the substance is only permitted on certain crops. Rice is not one of them. Unfortunately, the sales people on Raymondi street seem not be aware of this or do not care since they recommend products containing methamidophos to the rice farmers.

The recommendations in *Manejo integrado del cultivo arroz*, a book published by different Peruvian organizations and institutions, on how to fight the rice leafhopper[1] (*Tagosodes orizicolus*) and the rice leafminer[2] (*Hydrellia sp.)* can also be strongly questioned. The book was compiled in the year 2000 and the author of chapter 5 recommends that methamidophos and parathion-methyl should be used against those insects. The recommended doses are 0.60 kg/a.i/ha and 1.15 kg a.i/ respectively (Alva

[1] Sogata in Spanish
[2] La mosquilla o mosca minadora in Spanish

2000). Parathion has been banned in Peru since 1998 and methamidophos is not recommended for use on rice.

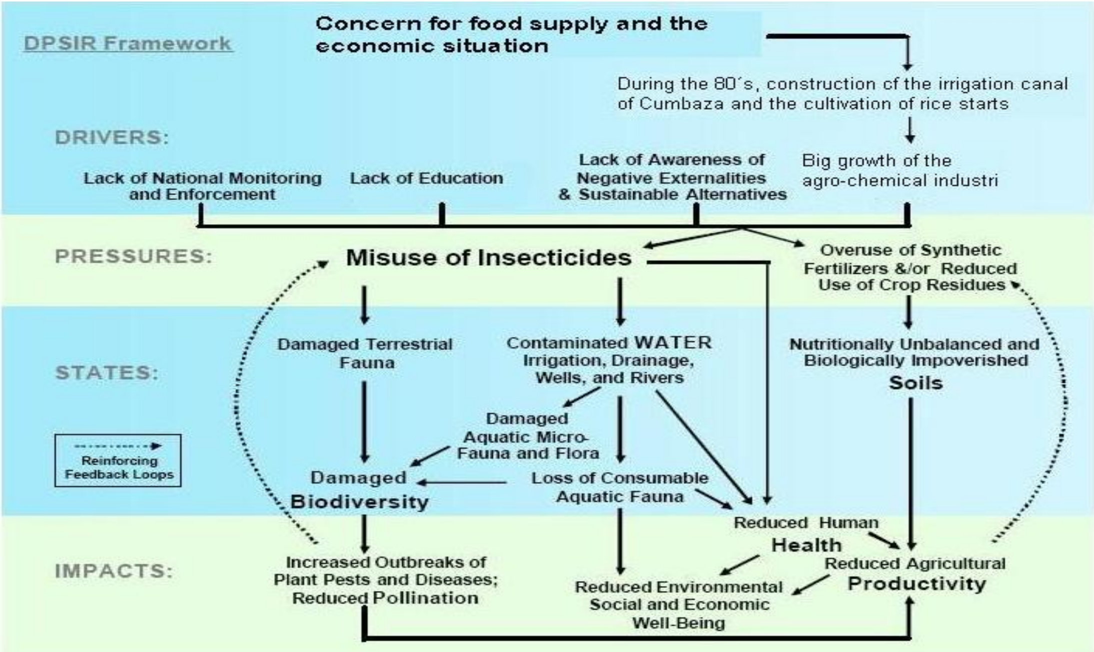


Figure 5. An estimated Root-Cause analysis in the Tarapoto region. (Modified from the GEF 2005)

5.2 Pesticide content

5.2.1 Water samples

The substances detected in the water with this method were α-endosulfan, β-endosulfan, endosulfan-sulfate, butachlor, paration-ethyl, alpha-cypermethrin, DDT-o,p, DDE-p,p, DDD-p,p, methamidophos, carbofuran, and carbosulfan. As Figure 7 shows, methamidophos carbofuran and carbosulfan are the most detected substances in the study. The endosulfans and its degradation product endosulfan-sulfate is the second most detected compound. Butachlor was mainly detected in surface waters and alpha-cypermethrin was only found in the special case of sample 11. The concentrations detected in the samples are showed in Appendix VII.

There was no possibility to determine the concentrations of methamidophos, carbofuran and carbosulfan due to a contaminated blank sample, although there were clear peaks of the substances in all of the chromatograms. As shown in Appendix XVI is the recovery of some of the active ingredients in the study is very low and for some of the substance is this method not reliable. This may be due to the limited experience of those involved in the field-work as the method has been tested and used in other circumstances with good results (Kylin 2007).

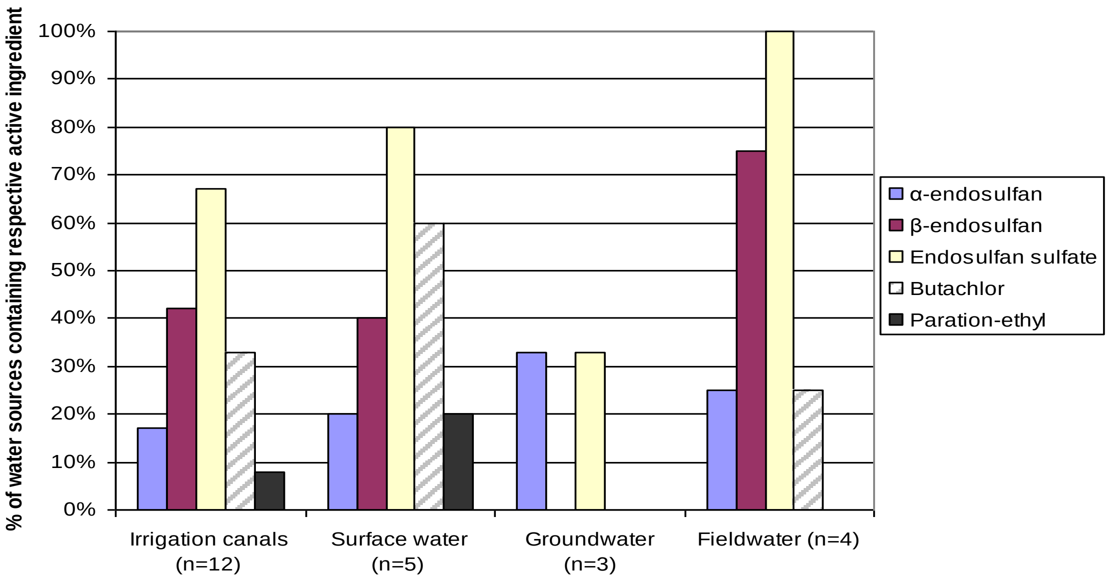


Figure 6. Results from water samples 1

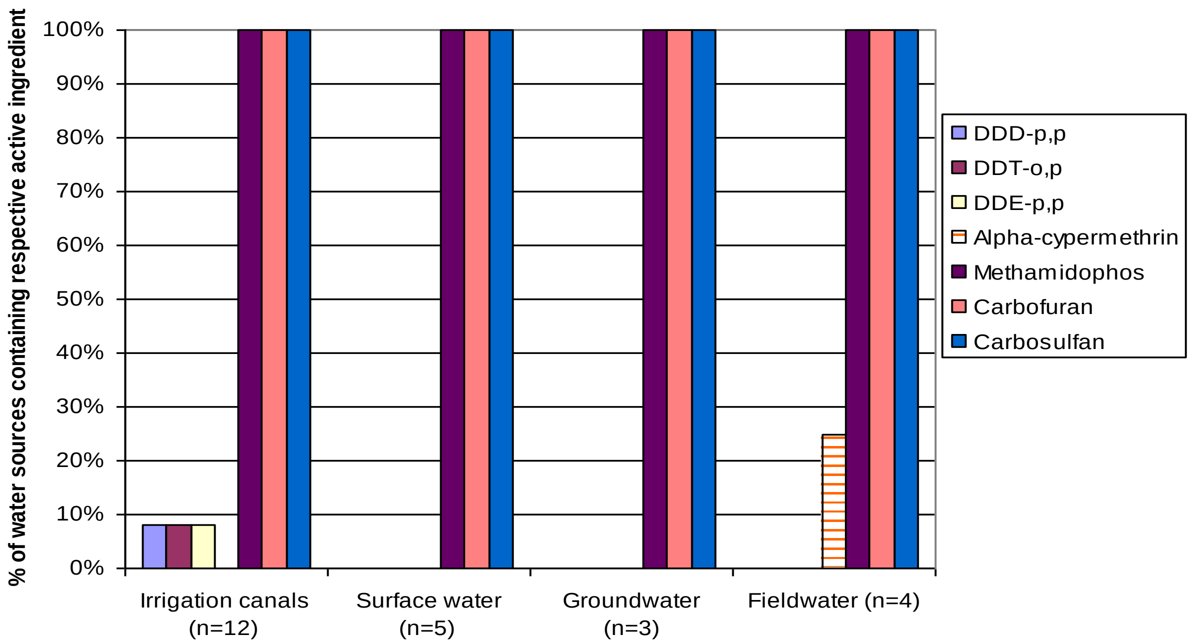


Figure 7. Results from water samples 2

5.2.2 Filter samples

Pesticides bound to particle from the filters were detected in five samples, in which two were pooled. Three of the samples were from field water. Figure 8 shows the detected substances and the concentrations. The high concentration of alpha-cypermethrin from the pooled filters 8 & 20 (0.29 µg/l) and the extreme value of the same substance in the special case of sample 11 (2.4 µg/l), have been taken away in the figures. There were also traces of methamidophos, carbofuran and carbosulfan in all samples. It was not expected to detect anything in the samples from the filter due to the small amount in some cases of suspended material. All the concentrations from the filter samples are shown in Appendix IX.

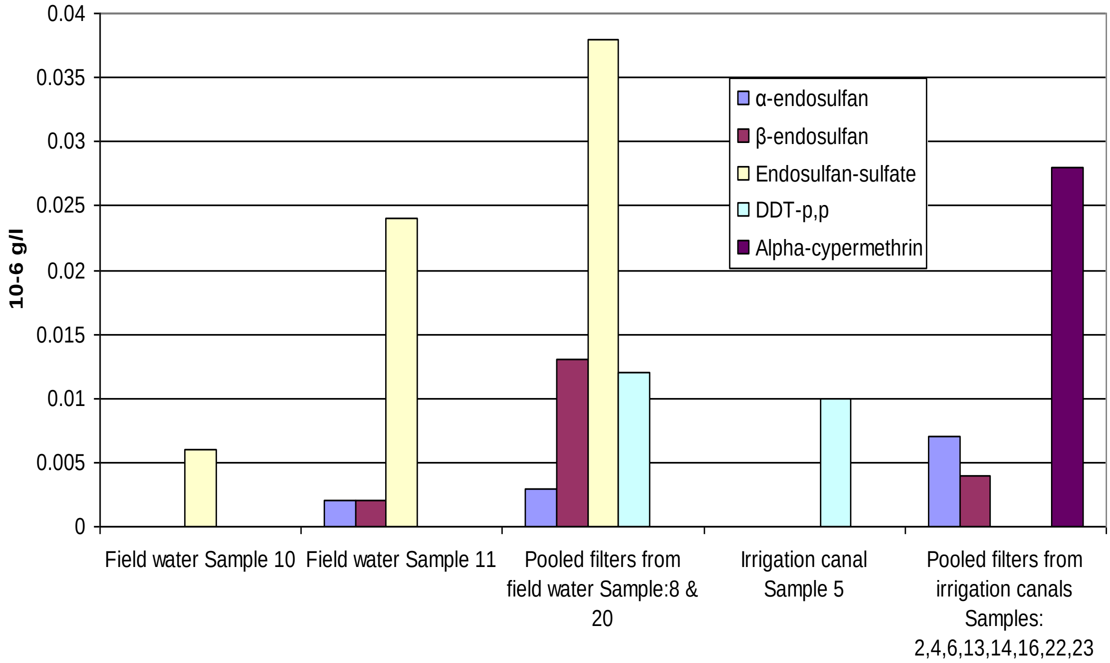


Figure 8. Results from filter samples

6. Discussion

6.1 Results from fields

The answers from the deep interviews and the use of pesticides are in line with other studies from tropical countries (Ntow 2001, GEF 2005, Palacio 2002). All the farmers in the study are using the pesticides in a manner that is both unsafe and inadequate. The lack of protective equipment is well known and difficult to overcome in hot climates. To call the pesticides "medicine for the plants" is a way to defuse their use and toxicity. The lack of access to adequate washing facilities, increasing of pests and depleted soils are another big problems connected to the rice cultivation in Tarapoto. It is not allowed to spray the field less than 30 days before harvest; something at least some of the farmers where aware of. In, e.g., California, rice farmers are required to stop water run-off from the fields following application of pesticides, if this is the case in Peru it is not known.

The high groundwater table can explain the detection of endosulfan, carbofuran, carbosulfan, and methamidophos in the groundwater close to Field 1. The more sandy soil compared to other groundwater sampling sites and the rain the day before the sampling can also be factors that can influence the results. In the almácigo from Field 1 are there concentrations of endosulfan in both the water and the filter samples. These residues are probably from the spraying of the field 75 days before the sampling. The main part of the degradation products seems to be attached to suspended particles from filters. In the almácigo, alpha-cypermethrin was also detected, probably from spraying a few days prior to the sampling.

The irrigation canals next to Field 2 contain the highest concentrations of total endosulfan of all the irrigation canals. The concentrations of all the pesticides detected are similar between the two canals. A possible explanation for that can be that the water from the canal where sample 22 was collected can be lead into irrigation canal where sample 23 was collected. Many fields are irrigated with this water. It is not permitted to spray less than 30 days before harvest. This time limit was broken on Field 2 that was sprayed 20 days before harvest.

The composite groundwater sample collected from Field 3, like all other samples, contains traces of carbofuran, carbosulfan and methamidophos. No other substances were detected, despite the high water table and abundant macro pores in the soil that can facilitate the transport and detection of compounds in the water. Sample 16 was collected from flowing water in Sub lateral 15 (San Antonio) next to Field 3. This sample was gathered a few hours after the trapdoor at the dam in Boca toma was reopened after 15 days of no new water in the principle canal. No or low concentrations of pesticides were expected due to the new flow of water directly from the principle canal and Lateral 15. There were signs of carbofuran, carbosulfan, methamidophos and DDE-p,p in this water sample.

It was surprising that there was no finds of endosulfan in the irrigation canals next to Field 4, but that substances like parathion-ethyl and metabolites of DDT were detected. A little house was situated next to Field 4 and unfortunately a baby was sitting outside during the spraying with bispyribac-sodium the sampling day. In the samples from the irrigation canals along Field 4, tadpoles were observed in samples 3 and 5. This was not the case in sample 4. An explanation for this can be the detection of parathion-ethyl in this canal. Parathion-ethyl seems not to be acutely toxic to some species of tadpoles, but has a high potential to accumulate in amphibians. Studies show that it can be more potentially hazardous to other organisms in the food chain by biomagnifications than for the tadpoles it self (Rusell 1990). It is known that parathion-ethyl has been used before on Field 4.

The effects of a compound can vary due to the partitioning of the compounds between different environmental compartments, and factors such as temperature and salinity may affect the partitioning. In general, higher temperature will increase the water solubility and the partitioning will favor the water phase. In contrast a higher salinity generally favors partitioning from the water into other media (particles, sediment, biota). An altered partitioning may also affect the toxic effects of a specific pesticide in the aquatic ecosystem. However, with current limited data is it difficult to predict what effect the high salinity of the Mishquiyacu Stream (4‰) may have on the toxicity of the pesticides.

In the irrigation canals of Fied 5 endosulfan-sulfate was the only endosulfan compound found. Endosulfan-sulfate is the final degradation product of endosulfan. The field has not been sprayed for approximately 2 months, which, perhaps, explains the absence of other endosulfan compounds. The water in these canals was also almost stagnant. The farmer owning this field, cooked lunch next to the field using empty pesticide bottles as fuel and washed the dishes in one of the irrigation canals.

There is a slight slope to the south-east down to the Cumbaza River. Fields 6 and 7 therefore have problems with too much water while the other rice farmers in the area struggle with water scarcity. The owner also declared that at the moment there is no possibility to grow other crops than rice in those fields due to the surplus of water. It was likely to detect higher concentrations of pesticides in samples connected to those fields because of their locations.

We expected to find pesticides in sample 17, next to Field 6. The shallow depth to groundwater, 18 mm of rain five days prior to the sampling, and that the water was sampled close to a spot where pesticides are mixed are factors that favourable contamination of water. Despite of this were there “only” traces of methamidophos, carbofuran and carbosulfan in the groundwater. The detection of those substances is likely to be traces of the applications of the insecticides *Tamaron* and *Marshal*, 22 respective 64 days before sampling. Heavy rains have probably facilitated the transport down the soil profile. The presence of a high content of organic material in the topsoil of the mixing point can be a factor that prevents further transport of pesticides from the mixing point through the profile. The detection of endosulfan and carbosulfan in the field water are likely from the last sprayings of the substances, 50 days respective 25 days before the sampling. The concentration differences between the endosulfans and endosulfan-sulfate between sample 10 and 11 is probably due to that sample 10 was collected downhill the field and sample 11 uphill.

The water from Field 7 shows the highest concentration of endosulfan-sulfate of all samples in the study. Despite this, a frog was seen on the field. The detection of endosulfan-sulfate is probably due to the spraying of endosulfan eight days before sampling. Samples 6 and 7 were from canals where the water has been stationary for 10 days. Endosulfan-sulfate was detected in those samples with the highest concentration of all samples from irrigation canals. It seems that it is a faster degradation of endosulfan on Field 7 compared to Field 6 (see further estimates). This conclusion is based on an estimate were the similar concentrations of endosulfan are expected on the field after spraying, and were almost the same concentrations are detected despite the big difference in the number of days after spraying, 50 respective 8 days (Appendix XIV).

The outlet for untreated wastewater and other waste products can be the reason for the low concentrations of pesticides from the sampling site at Santa Rosa de Cumbaza. The pesticides may bind to the particles instead of being dissolved in the water. Small fish were observed, but also dead tadpoles. The sample gathered at the Boca toma did not show any presence of pesticides except for carbofuran, carbosulfan and methamidophos. The detection of endosulfan in the principal canal indicates that the in- and out flow of water in the irrigation system is fairly unpredictable. Amphibians were seen in some places; a sign of not to heavily contaminated water since amphibians are very sensitive to toxic substances.

There is no pattern between the numbers of applications per harvest and concentrations detected in the study although the numbers of applications varies between 6 and 12 times. There are neither correlation between from which lateral the fields are irrigated, the allocation of the field and the results. The results from the study are fairly similar where no concentrations reach 1 µg/l, except for butachlor and alpha-cypermethrin. The degradation rate seems to be quite fast in the study area and a reason can be the wetland character of rice fields. It is well known that wetlands can have a filter effect that can decrease the concentrations of pollutants.

6.2 Information about the active ingredients detected

6.2.1 Butachlor

Butachlor is a selective systemic herbicide that is primarily absorbed by germinating shoots and secondarily by the roots. It is mainly used on paddy-rice and the effectiveness depends on the availability of water. The substance is stable to UV-light and the principally degradation of butachlor is by micro-organisms to water-soluble derivatives (The Pesticide Manual 2003).
According to Greenpeace (Greenpeace 1992) is butachlor mainly manufactured in Iowa by Monsanto, without being permanently registered in the U.S. In 1984 the Environmental Protection Agency in the US (USEPA) rejected Monsantos registration applications due to “environmental, residue, fish and wildlife, and toxicological concerns”. Butachlor is not on the WHO list of hazardous pesticides, but according to USEPA it is likely to be carcinogenic and has potential to leach into groundwater.

Table 13. Some characteristics of butachlor (The Pesticide Manual 2003) and conclusions according to FAO (FAO 2000)

Property	Parameter	Value	Conclusion
Degradation in soil[1]	$DT_{50\ SOIL}$	42-70 days	Fairly degradable
Solubility	S_w	20 mg/l	Readily soluble
Mobility	log K_{oc}	?	
Degradation in water	$DT_{50\ WATER}$	?	
Tendency to bioaccumulate[2]	log K_{ow}	***4.5****	May bioaccumulate

[1] The Californian Department of Pesticides Regulation has determined that a pesticide with a log K_{oc} <3.28 or with a half-life in water >14 days has potential to contaminate ground water. There is also potential of ground water contamination if the half-life in an aerobic soil is >690 days or >9 days in an anaerobic soil (PAN Pesticides Database 2007-02-18)
[2] A log K_{ow} >3 indicates a propensity to bioaccumulation (Australian Government 2007-04-22) Conclusion drawn by the author
[*] (SRC Phyapropdatabase 2007)

The sample with the highest concentrations of butachlor, was water from the stream of Mishquiyacu. The concentration reached 3 µg/l (Appendix VII). This is not surprising since there is an intensive use of the herbicide *Machete* along the stream. The dilution effect is much higher in the Mishquiyacu stream than in the irrigation canals, why it is surprising that the concentration differentiation is so large. The recovery of butachlor was only 26% in the recovery study, why the real concentration in all samples was probably higher than reported here (Appendix XVI). Due to the high log K_{ow}, there may be a potential for bioaccumulation, and the concentration of butachlor in Mishquiyacu can be a threat to the aquatic life, but depending on the rate of metabolism in specific organisms this may not be the case. There are also other factors that influence the potential for bioaccumulation, such as the degradation rate in the water. In the case of butachlor this parameter was not found in literature.

6.2.2 Endosulfan

Endosulfan is a non-systemic insecticide that was introduced in the 1950´s when the environmental awareness of the fate of chemicals was low. It was considered to be a safer alternative to the first generation organochlorine pesticides during the 70´s, but today endosulfan is considered one of the main sources of pesticide poising in developing countries (Gladstone et al. 2003). There are two forms of the compound, α and β, and the degradation product endosulfan-sulfate. Endosulfan is a candidate to be included in the Stockholm and the Rotterdam Conventions, since a scientific panel has recommended their inclusion. It is expected that there will be a ban of the compound during the 2008 Rotterdam Conference. The compound is widely considered to be a Persistent Organic Pollutant (POP), but has never appeared on the PIC-list. Many countries today have identified endosulfan as a hazardous substance and have banned or restricted its use. For example, endosulfan is not allowed on rice fields in Bangladesh, Indonesia, Korea and Thailand. Sweden banned the use in 1995, and Colombia, a neighbouring country to Peru, banned it in 1997. Endosulfan is forbidden in the European Union although some countries have an exemption; Italy, Spain, France and Greece are big consumers. Many countries that produced endosulfan during the 1970´s and 1980´s have stopped production. The main producers today are India, Israel, China and South Korea. Among the countries in the European Union, Germany is the only manufacturer, but Germany itself has banned the use (Usha et al. 2005).

Endosulfan is listed as one of the substances of priority list in the EU Water Framework Directive. The substance is acutely toxic for humans and has also been identified with a range of chronic effects including cancer and impacts on the endocrine system (Usha et al. 2005). Endosulfan degrades rapidly on plant surfaces. The main degradation in soil is by micro-organisms**.** Endosulfan is stable in sunlight, but unstable in alkaline media, and there is a slow hydrolysis in presence of vegetation (FAO 2000). The vaporizing to the atmosphere of endosulfan is limited.

The main degradation product of the compound is endosulfan-sulfate and that was also the most common endosulfan compound in this study. Bioaccumulation can occur in aquatic organisms and endosulfan is highly toxic to fishes and crustaceous even at recommended levels of application. National wildlife Federation in the U.S states that endosulfan is extremely toxic to wildlife and acutely toxic to bees.

Endosulfans were mainly detected in water samples from the fields. The highest concentrations were detected in the water from Fields 6 (samples 10 and 11) and 7 (sample 8) were endosulfan had been sprayed 50 respectively 8 days before sampling. The concentrations of endosulfan in water from other fields are unknown. Endosulfan was also the most detected substance on the particles from the filter. The slight solubility and mobility of endosulfan make it reasonable to find the substance in both the water and adsorbed to soil particles. According to FAO the risk for leaching into groundwater should be small; despite of this endosulfan was found in groundwater in this study. The detection of endosulfan in the groundwater close to Field 1 (sample 18) is alarming. Households close to Field 1 use the groundwater as drinking water and there were discussions a few years ago about drilling a well here. One thing to consider is that the concentration sum of endosulfan in ground water sample number 18 was 0.0034 µg/l. This concentration is notable close to 0.005 µg/l, the Swedish environmental quality criterion for surface water.

Table 14. Some characteristics of endosulfan and conclusions according to FAO (FAO 2000)

Property	Parameter	Value	Conclusion
Degradation in soil[1]	$DT_{50\ SOIL}$	60-800 days	Slightly degradable
Solubility	S_w	0.5 mg/l	Slightly soluble
Mobility[1]	Log K_{oc}	3.4	Slightly mobile
Degradation in water[1]	$DT_{50\ WATER}$	streams: 5.7 days rivers: 7.2 days lakes: 304 days	
Tendency to bioaccumulate[2]	Log K_{ow}	A=4.74* β=4.79*	May bioaccumulate

[1] The Californian Department of Pesticides Regulation has determined that a pesticide with a log K_{oc} <3.28 or with a half-life in water >14 days has potential to contaminate ground water. There is also potential of ground water contamination if the half-life in an aerobic soil is >690 days or >9 days in an anaerobic soil (PAN Pesticides Database 2007-02-18)
[2] A log K_{ow} >3 indicates a propensity to bioaccumulation (Australian Government 2007-04-22)
Conclusion drawn by the author
* (The Pesticide Manual 2003)

6.2.3 Paration-ethyl

Paration-ethyl or *Parathion*, is an non-systemic organophosphate insecticide. This group of insecticides is widely used among small farmers in developing countries and most of the insecticide poisonings related to agriculture are due to organophosphate exposure (Gladstone et al. 2003). A reason for this is that they are cheap and easily available. Many of the most commonly used have high acute toxicity. They are inhibitors of cholinesterase, an enzyme required for nerve functions, and they may also be carcinogenic to humans. Parathion-ethyl is ranked as one of the most hazardous compounds to ecosystems and human health; it is highly toxic to birds, fish, and small mammals and very highly toxic to pollinating insects.

Parathion-ethyl is strongly adsorbed to soil particles. Adsorption to suspended particles and bottom sediments is therefore the principal removal process in open water. Degradation is faster in flooded soils and increases with increasing pH (FAO 2000). The degradation appears to be dependent on the microbiological activities, the soil sorption, and, to a lesser extent, photo-degradation (EPA 2000). According to the Environmental Fate and Effects Division (EFED) connected to EPA, parathion-ethyl constitutes a threat of surface water contamination under some conditions. These include poorly drained or wet soils with readily visible slopes toward adjacent surface waters, frequently flooded areas, areas overlaying extremely shallow ground water, areas with in-field canals or ditches that drain to surface water, areas not separated from adjacent surface waters with vegetated filter strips, and areas overlaying tile drainage systems that drain to surface water (EFED 1999). Almost all of those conditions fit the description of the study area. According to USEPA, protective clothing and equipment is not sufficient to reduce the risk to people working with application to an acceptable level. To reduce the risk of exposing people to parathion-ethyl involved in the use, EPA recommend a time limit for entering a sprayed field of >45 days (EPA 2000), while FAO has a time limit of only 48 h (FAO 1997).

A peón working on one of the fields in the study was intoxicated in 1997 by *Parathion* and was hospitalized for 3 days. Another peón had a relative that died from dermal uptake after *Parathion* had leaked from the broken backpack sprayer onto his back. In 1999, 22 children fatally intoxicated by parathion-ethyl in Cuzco. The substance was banned in Peru in 1998, a year before the tragic accident. It was banned in Sweden in 1971.

Table 15. Some characteristics of parathion-ethyl and conclusions according to FAO (FAO 2000)

Property	Parameter	Value	Conclusion
Degradation in soil[1]	$DT_{50\ SOIL}$	7 days	Readily degradable
Solubility	S_w	11 mg/l	Readily soluble
Mobility[1]	Log K_{oc}	3.5	Slightly mobile
Degradation in water[1]	$DT_{50\ WATER}$	1-10 days	
Tendency to bioaccumulate[2]	Log K_{ow}	3.83*	May bioaccumulate

[1] The Californian Department of Pesticides Regulation has determined that a pesticide with a log K_{oc} <3.28 or with a half-life in water >14 days has potential to contaminate ground water. There is also potential of ground water contamination if the half-life in an aerobic soil is >690 days or >9 days in an anaerobic soil (PAN Pesticides Database 2007-02-18)
[2] A log K_{ow} >3 indicates a propensity to bioaccumulation (Australian Government 2007-04-22) Conclusion drawn by the author
* (The Pesticide Manual 2003)

The detection of parathion-ethyl in the water sample from the stream of Mishquiyacu is surprising and serious. The substance is relative readily degradable in both soil and water, and it appears that parathion-ethyl has been used quite recently**.** In an irrigation canal connected to Field 4 was 0.024 µg/l of parathion-ethyl detected. There seems to be an illegal use in small scale in the study site regardless of the ban. According to the characteristics of the substance there is a risk of leaching into the groundwater although it is limited.

6.2.4 Methamidophos

Methamidophos is, similarly to parathion-ethyl, an organophosphate, but also a metabolite from the pesticide acephate. It is a broad-spectrum systemic insecticide and also one of the most acutely toxic ones to humans. Methamidophos is usually used on potatoes, tomatoes and cotton and restricted in many countries to a few crops. Degradation of methamidophos is slow in sandy soils. It is higher in loamy sands and reaches the peak in silt loam. The substance is rapidly degraded in air due to photochemical processes, and this is the principle degradation process (FAO 2000). Data show that methamidophos is slightly toxic for freshwater fish and acutely toxic to aquatic invertebrates and different kinds of birds. Application close to surface water can be dangerous for the aquatic fauna. Up to 82 µg/l of methamidophos was detected in irrigation canals from rice fields in Costa Rica. The substance has contaminated watercourses and vegetables, and caused death for people and animals (IRET-UNA 2004).

To reduce the risk of human exposure to methamidophos, FAO recommends that a sprayed field should not be entered for 48 h (FAO/PIC 1997). As mentioned above, methamidophos is one of the most used compounds at the study site, despite that its use on rice is not allowed.

Table 16. Some characteristics of methamidophos and conclusions according to FAO (FAO 2000)

Property	Parameter	Value	Conclusion
Degradation in soil[1]	$DT_{50\ SOIL}$	<2days*	Readily degradable
Solubility	S_w	>2 000 000 mg/l	Highly soluble
Mobility[1]	Log K_{oc}	0.58	Highly mobile
Degradation in water[1]	$DT_{50\ WATER}$	5-27 days* (pH 7)	
Tendency to bioaccumulate[2]	Log K_{ow}	-0.8*	Will not bioaccumulate

[1]The Californian Department of Pesticides Regulation has determined that a pesticide with a log K_{oc} <3.28 or with a half life in water >14 days has potential to contaminate ground water. There is also potential of ground water contamination if the half life in an aerobic soil is >690 days or >9 days in an anaerobic soil (PAN Pesticides Database 2007-02-18)
[2] A log K_{ow} >3 indicates a propensity to bioaccumulation (Australian Government 2007-04-22)
Conclusion drawn by the author
* (The Pesticide Manual 2003)

Even though methamidophos is rather rapidly degraded in both soil and water, traces of this compound were, surprisingly, detected in all water and filter samples. The high solubility and the low log K_{oc} value make the substance highly mobile with water which may explain the detection of the substance in all samples. Methamidophos has virtually no bioaccumulation potential.

Most curious is the detection of methamidaphos in the field water and on the filters from Fields 1, 6 and 7 where the substance has not been used for a long time. An exception is Sample 11 that was collected right after spraying with methamidophos from Field 6. These results may be due to a substantial recycling of the water between the fields.

6.2.5 Carbosulfan

Carbosulfan is a systemic broad-spectrum insecticide with contact and stomach action belonging to the carbamates. It is mainly used on potatoes, sugar beet, citrus, rice and maize and as seed dressing. Carbosulfan is highly toxic to birds and aquatic life and should therefore be carefully applied close to water sources.

The substance is not soluble in water. In spite of this, carbosulfan was detected in all the water and filter samples. Although the high K_{ow} indicates a risk for bioaccumulation, the degradation of carbosulfan in water is rapid and bioaccumulation is probably not a problem in the aquatic environment. The detection of carbosulfan in the groundwater was not expected due to the high log K_{oc}-value and the degradation rate in water.

Table 17. Some characteristics of carbosulfan (The Pesticide Manual 2003) and conclusions according to FAO (FAO 2000)

Property	Parameter	Value	Conclusion
Degradation in soil[1]	$DT_{50\ SOIL}$	3-30 days	Readily/Fairly degradable
Solubility	S_w	3 µg/l	Not soluble
Mobility[1]	log K_{oc}	***~ 4****	Hardly Mobile
Degradation in water[1]	$DT_{50\ WATER}$	11.4 hours	
Tendency to bioaccumulate[2]	log K_{ow}	5.4	May bioaccumulate

[1]The Californian Department of Pesticides Regulation has determined that a pesticide with a log K_{oc} <3.28 or with a half-life in water >14 days has potential to contaminate ground water. There is also potential of ground water contamination if the half-life in an aerobic soil is >690 days or >9 days in an anaerobic soil (PAN Pesticides Database 2007-02-18)
[2] A log K_{ow} >3 indicates a propensity to bioaccumulation (Australian Government 2007-04-22) Conclusion drawn by the author
* (University of Hertfordshire & Footprint 2007)

6.2.6 Carbofuran

Carbofuran is the main metabolite of carbosulfan and is itself a pesticide. It is formed through a cleavage of the N-S bond in carbosulfan (Appendix XVII). Despite of this, carbosulfan is at the moment permitted in Sweden but not carbofuran. Products containing carbofuran were introduced on the market in 1965. Carbofuran is a carbamate that is unstable in alkaline media. The main degradation in water is chemical hydrolysis in alkaline conditions, but photo degradation and aquatic microbes may also contribute (Extoxnet 1996). The substance has a half-life of > 4 days if it is applied on leafs. Similar to the mother substance, it is highly toxic to fish and many birds. According to the Ecological Incident Investigation System in the U.S., carbofuran has been responsible for more avian deaths than any other pesticide (ABC 2007-03-01). Application on rice with carbofuran should take place 21 days before or within flooding. Unprotected persons should be kept out of treated area for at least one day (IPCS 2007-03-02).

The toxicity of the compound is similar to carbosulfan, but it is slightly more toxic to terrestrial organisms. Although there is physical similarity between the compounds, they behave differently in the environment. While carbosulfan adsorb strongly to the soil, carbofuran is mobile.

An important legislation, Directive 91/414/EEC, came into force in The European Union on 26 July 1993. One of the purposes with this directive was to establish a positive list of active substances, (called the Annex I), that have been shown to be without unacceptable risk to people or the environment. Member states in the EU can only authorize the marketing and use of pesticide products when an active substance is listed in Annex I, except where transitional arrangements apply. In November 2006, the Standing Committee on the Food Chain and Animal Health in the European Commission voted for the non-inclusion of carbosulfan and carbofuran in Annex I of Directive 91/414/EEC. This is because it was not possible to conclude that carbosulfan met the safety criteria to be included on the basis of the information available. The information can be such as the physical and chemical properties of the compound, effects of target pests, risk assessment etc. The decision of the European

Commission will be published up to 6 months after the vote at the Standing Committee on the Food Chain and Animal Health (about June 2007) (PSD 2007). In the U.S. there is also a discussion about cancelling the registration and use of carbofuran.

Table 18. Some characteristics of carbofuran and conclusions according to FAO (FAO 2000)

Property	Parameter	Value	Conclusion
Degradation in soil[1]	$DT_{50\ SOIL}$	30-117 days	Moderately degradable
Solubility	S_w	320 mg/l	Readily soluble
Mobility[1]	log K_{oc}	1.3	***Mobile***
Degradation in water[1]	$DT_{50\ WATER}$	River: 2 hours lake: 6 hours sea water: 12 hours	
Tendency to bioaccumulate[2]	log K_{ow}	1.52*	Low propensity to bioaccumulate

[1]The Californian Department of Pesticides Regulation has determined that a pesticide with a log K_{oc} <3.28 or with a half-life in water >14 days has potential to contaminate ground water. There is also potential of ground water contamination if the half-life in an aerobic soil is >690 days or >9 days in an anaerobic soil (PAN Pesticides Database 2007-02-18)
[2] A log K_{ow} >3 indicates a propensity to bioaccumulation (Australian Government 2007-04-22)
Conclusion drawn by the author
* (The pesticide manual 2003)

The possibility to detect the substance in water should be limited due to the fast degradation. In spite of this, carbofuran is detected in all water samples. Due to the low log K_{oc} value, the substance is mobile and has potential to contaminate groundwater. There is a low propensity to bioaccumulate due to the low K_{ow}.
The detection of carbosulfan and carbofuran in the samples can be due to contamination.

6.2.7 DDT

DDT is a persistent, non-systemic insecticide with contact and stomach action. It was introduced in the early 1940´s and the discovery of its insecticidal action was rewarded the Nobel price in physiology or medicine in 1948 (Nobelprize 2007-05-16). DDT was introduced as vector control of insect borne diseases such as malaria and typhoid. In the 1970s and 1980s the agricultural use of DDT was banned in most industrialized countries because of its environmental impacts and high risk for biomagnifications. Sweden and Norway were the first countries to ban DDT in the early 70´s. DDT has been replaced by less persistent and more expensive insecticides, e.g., organophosphates and pyrethroids. Unfortunately, it has been difficult to find a substitute with the same effectiveness as DDT that is less dangerous for the human health and environment. In a province in South Africa, e.g., the number of malaria cases increased from 8000 to 42000 when they stopped to use DDT in 1996 (Tren & Bate 2004). There are still some tropical countries that are in need to use DDT to avoid big malaria outbreak, but there is a big difference between how DDT is used today and the former wide spread use in agriculture. Use of DDT for vector control is primarily done inside buildings and with selective spraying. In some areas DDT has lost much of its efficacy due to resistance development. The global climate change may give rise to an increasing use of DDT due to an expected increase of malaria. The main component of DDT is p,p-DDT which was the most detected DDT-compound in this study. Biodegradation of DDT is faster in flooded soils and under anaerobic conditions, but generally very poor in water (FAO 2000). The substance adsorbs strongly to sediments and is subject for bioaccumulation in fish and other organisms. DDT is resistant to break down by light and oxidation but may volatilize to air.

Table 19. Some characteristics of DDT and conclusions according to FAO (FAO 2000)

Property	Parameter	Value	Conclusion
Degradation in soil[1]	$DT_{50\ SOIL}$	4-30 years (faster in tropical countries)	Very slightly degradable
Solubility	S_w	0.0033 mg/l	Not soluble
Mobility[1]	log K_{oc}	6.2 (p,p-DDT 5.4)[*]	Not mobile
Degradation in water[1]	$DT_{50\ WATER}$	Through hydrolysis: 12 years By light in aqueous solution: >150 years	Very slightly degradable
Tendency to bioaccumulate[2]	log K_{ow}	p,p-DDT 6.19[*]	High risk of bioaccumulation

[1]The Californian Department of Pesticides Regulation has determined that a pesticide with a log K_{oc} <3.28 or with a half-life in water >14 days has potential to contaminate ground water. There is also potential of ground water contamination if the half life in an aerobic soil is >690 days or >9 days in an anaerobic soil (PAN Pesticides Database)
[2] A log K_{ow} >3 indicates a propensity to bioaccumulation (Australian Government 2007-04-22) Conclusion drawn by the author
[*] (Mackay et al. 1997)

Three other DDT-compounds (DDT-o,p, DDE-p,p and DDD-p,p) were detected in two of the water samples. This was not expected due to the low solubility and the high log K_{oc} of the compound. The highest recovery for the metabolites of DDT was only 14% with this method in this study.

DDT-p,p was detected on particles from filter samples from irrigation canal 5 and from a pooled filter sample from two fields. The concentrations in these samples (0.010 respectively 0.012 µg/l) are 10 times the value for chronic toxicity to aquatic organisms in surface waters. The use of DDT is forbidden in Peru since 1991 and it is not even used in vector control. Due to the low mobility, solubility and degradation, the source of the DDT may be old sins that have been accumulated in sediments and are released continuously.

6.2.8 Alpha-cypermethrin

Alpha-cypermethrin is a broad-spectrum contact and ingestion insecticide. It is a synthetic pyrethroid and consists of the two cis-isomers of the eight isomers present in cypermethrin. Alpha-cypermethrin has been widely used in agricultural crops, forestry as well as in public and animal health since 1983 (FAO 1997). It is highly stable to light and elevated temperatures and the half-lives are similar in aerobic and anaerobic conditions. The compound is also stable under acidic and neutral condition (pH 3-7). According to IPCS it is “unlikely that alpha-cypermethrin, with recommended application rates, attains levels of environmental significance. Significant toxic effects on non-target invertebrates and fish are only likely to occur in cases of spillage, overspraying and misuse”. However, as alpha-cypermethrin is highly toxic to aquatic arthropods, fish and honeybees under laboratory conditions (IPCS 2007-03-05), the consequences may be sever in cases of accidents or misuse. It seems that the compound is not highly toxic to birds, but according to the log K_{ow} has it high tendency to bioaccumulation, however, as it contains an ester that can be hydrolyzed, bioaccumulation is in fact low. Alpha-cypermethrin is in general permitted to use in the European Union and also in Sweden.

Table 20. Some characteristics of alpha-cypermethrin (The Pesticide Manual 2003) and conclusions according to FAO (FAO 2000)

Property	Parameter	Value	Conclusion
Degradation in soil[1]	$DT_{50\ SOIL}$	91 days loamy soil	Slightly degradable
Solubility	S_w	3.97 mg/l	Moderate soluble
Mobility[1]	Log K_{oc}	***4.4-5.1****	Hardly mobile
Degradation in water[1]	$DT_{50\ WATER}$	101 days, pH 7	Very stable
Tendency to bioaccumulate[2]	Log K_{ow}	6.94	High propensity to bioaccumulate

[1]The Californian Department of Pesticides Regulation has determined that a pesticide with a log K_{oc} <3.28 or with a half-life in water is >14 days has potential to contaminate ground water. There is also potential of ground water contamination if the half life in an aerobic soil is >690 days or >9 days in an anaerobic soil (PAN Pesticides Database 2007-02-18)
[2] A log K_{ow} >3 indicates a propensity to bioaccumulation (Australian Government 2007-04-22)
Conclusion drawn by the author
* (European Commission 2005)

In this study, alpha-cypermethrin was detected in one water sample and three filter samples. The find of the substance in the water sample 11 is a special case. The sample was collected directly after Field 6 had been sprayed with alpha-cypermethrin and 5.6 mm of rain had fallen. Concentrations in the water and on the filter were 3.1 respective 2.3 μg/l (see estimations). Alpha-cypermethrin adsorbs strongly to soil particles and is hardly mobile and should not be a direct threat to the ground water.

6.3 Guidelines for surface waters

Water quality guidelines are recommended values or ranges for a parameter, e.g. pH, concentrations of compounds, turbidity, traces of faecal bacteria etc. that should not be exceeded or fall below. Guidelines for pesticides have been set in different countries as a tool to avoid contamination of surface water.

EU Environmental Quality Standards (EQS) values are only available for the EU Priority substances. For the active ingredients without values there are no standard EQS set. At the moment endosulfan is the only one of the detected compounds on the list of priority substances. According to the European Drinking Water Directive the limit for pesticides in drinking water is 0.1 μg/l for all individual compounds and 0.5 μg/l for the sum of pesticides or their metabolites. The limits were introduced in 1980 without consideration of any toxicity data, but indicating what was thought to be attainable detection limits for environmental laboratories and with a wish to have "clean" drinking water.

Table 21. Different environmental quality criteria for surface waters; Standards from Sweden, the Environmental Quality Standard for the European Framework for water (WFD), Water Quality Criteria from USEPA and the results in the study

Active ingredient	Swedish standard criteria for surface water[1] (µg/l)	EQS WFD[2] ***(µg/l)***	***WQC, USEPA[4]***		***Concentrations detected in the surface water in the study (µg/l)***
			Acute ***(µg/l)***	Chronic ***(µg/l)***	
Butachlor	-	-	-	-	0.076; 0.078 and 2.988
α-endosulfan	0.005 [3]	0.004	0.22	0.056	0.006
β-endosulfan	0.005 [3]	0.004	0.22	0.056	0.003 and 0.006
Endosulfan-sulfate	0.005 [3]	0.004	-	-	0.010; 0.015, 0.021 and 0.047
Σ endosulfan	-		0.22	0.056	0.053 (highest)
Parathion-ethyl	-	0.002[5]	0.065	0.013	0.063
Carbosulfan	0.01	-	-	-	Traces
Carbofuran	0.3	-	-	-	Traces
Methamidophos	-	-	0.00022[6]	-	Traces
Alpha-cypermethrin	0.001	-	-	-	3.138*
Σ DDT	-	-	1.1	0.001	0.003** and 0.010**

[1] Riktvärden för ytvatten (KemI uppdaterad 2007-05-14)
[2] EQS developed for the Water Framework Directive of the EU by Lepper 2002
[3] Developed by Asp & Kreuger 2005
[4] Developed for USEPA by Nowell and Resek 1994, Acute and chronic are established concentration below which adverse effects on aquatic organisms are not expected for acute or chronic exposure
[5] Critical concentrations for crustaceans (Notenboom et al. 1999)
[6] Acutely to larval crustaceans in 96-hour toxicity tests (Juarez et al. 1989)
* Sample from field water
** Samples from irrigation canal

The concentrations of endosulfan in the study are slightly higher than the standard criteria in Sweden and in Europe, but lower than in the U.S. The stream Codo Seco (sample 12) shows the highest concentration of total endosulfan of all the surface waters in the study with 0.053 µg/l. As shown in Table 21 was parathion-ethyl detected in the stream of Mishquiyacu (sample 9) with a concentration of 0.063 µg/l. According to USEPA the concentrations of endosulfan and parathion-ethyl may be a chronic (endosulfan) or an almost acute (parathion-ethyl) threat to the aquatic organism health in the stream. The concentration of metabolites of DDT in sample 3 can be of chronic threat to aquatic life. In this irrigation canal were tadpoles observed and there can be a risk of biomagnification. To decrease the concentration of alpha-cypermethrin in water sample 11 from Field 6 (3.1 µg/l) to the Swedish standard criteria for surface water (0.001 µg/l) is more than 3 900 000m^3 of water needed. In a situation of carelessness, high precipitation and bad luck can it be possible that field water on Field 6 can reach the stream of Mishquiyacu directly after spraying.

The Swedish standards and the EQS in the European Framework Directive are considerable lower than the USEPA criteria. This is a sign of the uncertainty and lack of knowledge in the area. The EQS criteria are sometimes lower than the detection limit. This is a problem because the substance can be present in a toxic concentration but still not detectable. In that case biological test is the only method to measure toxicity. Some pesticides can also be toxic close to the detection limit. An additional problem is that the standards do not take into consideration combination effects with other stress factors, e.g., how a specific concentration affects animals that are already ill or weak. It seems that international institutions focus on the acute effects of pesticides, the long-term effects is often forgotten. A standard terminology for pesticide residues in water is needed as different countries have their own "experiments" and definitions. The limits are because of this in a wide range when they should be the same. The differences are sufficiently large to be a major problem in discussing environmental problems.

6.4 Conventions connected to the pesticides detected

Some international conventions exist with the purpose to control the production and trade of the most toxic pesticides. The conventions will work as a tool to decrease the risks of accidents caused by pesticides and encourage governments to implement restrictions and suitable management for chemicals. For example, the Rotterdam Convention on Prior Informed Consent (PIC), which entered into force in February 2004 regulates the international trade of parathion-ethyl, methamidophos and carbofuran. If two countries in two regions of the world have banned the pesticide, the pesticide is put on the PIC list as a precaution to other countries about the risk of the chemical. The PIC list is a way to control and monitor the trade and use of highly toxic chemicals. Countries that export chemicals on the PIC list must inform the importing country about the listing. The importing country can than refuse to have trade with chemicals on the PIC list. The use and production of DDT and other persistent organic pollutants (POPs) are strictly limited by the Stockholm Convention, which entered into force in May 2004. As shown in Table 22 the Rotterdam Convention also regulates DDT. Peru ratified the Rotterdam Convention and the Stockholm Convention in August 10, 2005. The ratification of the Rotterdam Convention can be an important step to decrease the use of methamidphos, carbofuran and, hopefully, endosulfan. If a ban is introduced for some of these pesticides, the rice farmers will be obliged to start to use other pesticides. The out-phasing process will difficult due to the high use. As mention above, the WHO classification is mainly based on the oral LD_{50} for rats, but other evaluations are also taken in consider. For example parathion-ethyl has an LD_{50} -value of 13 mg/kg, but is classified as extremely hazardous all the same.

6.5 Code of Conduct on the distribution and use of pesticides

FAO introduced an international Code of Conduct (CoC) on the distribution and use of pesticides in 1985. There are voluntary standards of conduct for all public and private institutions involved in the distribution and use of pesticides (FAO 2005). The CoC includes, e.g., labelling, packaging, advertising, trade, distribution, management and how to reduce health and environmental risks. It requires a shared responsibility of the society and emphasizes cooperation between exporting and importing countries, the pesticide industry, traders, users, environmental organizations, food industry etc.

Item 7.5 in Article 7; *Availability and use,* states:

"Prohibition of the importation, sale and purchase of highly toxic and hazardous products, such as those included in WHO classes Ia and Ib, may be desirable if other control measures or good marketing practices are insufficient to ensure that the product can be handled with acceptable risk to the user".

Photo 19 shows a bottle of Tamaron that was for sale in the Raymondi Street in Tarapoto. Tamaron contains the active ingredient methamidophos that is classified according to WHO as Ib, highly hazardous (WHO 2004). Despite this Bayer CropScience claim that they follow the CoC on their website (Bayer 2007-08-31).

Photo 18. Inside an agro-store along the Raymondi street, Tarapoto
Source: Agneta Andersson

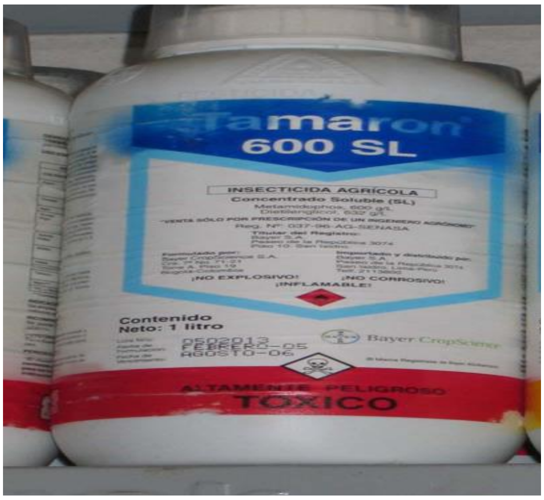


Photo 19. Tamaron, one of the most sold pesticides in the study area

Table 22. Some information about the detected pesticides in the study

Active ingredient	Pesticide type	Pesticide group	Banned in Sweden[1]	Banned in EU[2]	Banned in Peru[3]	Probably Endocrine-disruptor[4]	Included in the Rotterdam Convention[5]	Included in the Stockholm Convention[6]	LD_{50} mg/kg[7]	WHO classification[7]
Endosulfan (α,β and sulfate) $C_9H_6Cl_6O_3S$	Insecticide	Cyclodiene organochlorine	Yes	Yes, but with national exemptions	No	Yes	No but probably soon	No but probably soon	80	II
Butachlor $C_{17}H_{26}ClNO_2$	Herbicide	Chloroacetamide	No (not registered)	No	No	-	No	No	3300	U
Parathion-ethyl $C_{10}H_{14}NO_5PS$	Insecticide	Organophosphate	Yes	No but severe restricted	Yes	Yes	Yes	No	13	Ia
Methamidophos $C_2H_8NO_2PS$	Insecticide	Organophosphate	Yes	No	No but under restriction	-	Yes	No	30	Ib
Carbofuran $C_{12}H_{15}NO_3$	Insecticide	Carbamate	Yes	No but probably soon	No	Yes	No	No	8	Ib
Carbosulfan $C_{20}H_{32}N_2O_3$	Insecticide	Carbamate	No but soon	No but probably soon	No	-	No	No	250	II
DDT $C_{14}H_9Cl_5$	Insecticide	Organochlorine	Yes	Yes	Yes	Yes	Yes	Yes	113	II
Alpha-cypermet. $C_{22}H_{19}Cl_2NO_3$	Insecticide	Pyrethroid	No	No	No	-	No	No	79	II

[1](KemI, Bekämpningsmedels registret 2007-02-21)
[2](PAN UK 2005)
[3](SENASA 2007-06-01)
[4](PAN UK 2005)
[5](The Rotterdam Convention 2007-05-21)
[6](Stockholm Convention on persistent organic pollutants 2007-05-20)
[7](WHO 2004)

6.6 Spraying pattern and estimations

6.6.1 An example of a spraying schedule

Table 23. An example of the consumption of pesticides on Field 6

Order of spraying	Date	Age of rice (days)	Type	Name (risk class)	Active substance	Amount used (ml/ha or g/ha)	Conc. of active substance
1	25 April	50	I	Thiodan35EC (II)	endosulfan	500 ml	350 g/l
				Cigaral35EC (II)	imidacloprid	100 g	350 g/l
			F	Antracol700WP (U)	propineb	1000 g	700 g/kg
2	20 May	75	I	Marshal25EC (II)	carbosulfan	500 ml	250 g/l
			F	Fordazim5FW (U)	carbendazim/benza midasole	500 ml	50 g/l
3	14 June	100	I	Stermin600SL (Ib)	methamidophos	750 ml	600 g/l
				Fastac (II)	alpha-cypermethrin	250 ml	100 g/l
			F	Fordazim5FW (U)	carbendazim/benza midasole	500 ml	50 g/l
				Folicur250EW (III)	tebuconazole	250 ml	250 g/l
			Growth stimulant	Stimplex	cytokinin (group of substance)	250 ml	
			Fertilizer	Belfruto	N, P, K etc.		
4	29 June	115	I	Stermin600SL (Ib)	methamidophos	750 ml	600 g/l
			F	Antracol700WP (U)	propineb	1000 g	700 g/kg
				Lancer* (II)	imidacloprid	100 g	35%
			Fertilizer	Quimifol*	N, P, K, etc.		
				Urea			

* Used if necessary

Herbicides like *Hedonal* (2,4-D, phenoxycarboxylic acid), *Machete* (butachlor), *Nominee* (bispyribac sodium) and *Round-up* (glyphosate) are used along the field borders. As fertilizers *Urea* (46% N) and *SUL-PO-MAG* (22% S, 22% K_2O, 18%

MgO) in sacks of 50 kg are used. Usually are 200 kg urea per/ha used per harvest season.

The farmer is using in total at least 4 litres pesticides/ha/harvest and 2.1kg/ha/harvest, which will give a use of 8 litres of pesticides/ha/year and 4.2 kg. If all the members of the committee of Rosanayco are using the same amount on the 475 ha of rice, which is realistic or even conservative estimate, the total use in the area will be around 3800 litres of pesticides/year.

6.6.2 Estimates from Field 6

6.6.2.1 Estimates of degradation/dissipation of endosulfan

Application of endosulfan on Field 6 (2.5 ha) 25/4-05

Two barrels filled with a total of 360 l water are used

Sampling: 14/6-05 i.e. 50 days after application

Thiodan: $C_{1\ (endosulfan)}$ = 350 g/l, $V_{1(endosulfan)}$ = 1 l

$C_{2(endosulfan)}$ = The new concentration in the barrel, $V_{2(volume\ water\ +\ pesticide)}$ = 360 l + 2 l

$C_1V_1 = C_2V_2 \rightarrow 350$ g/l * 1 l = C_2 * 362 l
C_2 = 0.97 g/l

Estimated height of water on the field: 5 cm

Volume water on 2.5 ha field = 2500 dm*1000 m*0.5 dm = 1250000 dm^3

$C_1V_1 = C_2V_2 \rightarrow 0.97$ g/l * 362 l = C_2 *1250000l

Concentration of endosulfan in the field, C_2 = 0.00028 g/l = 280 µg/l

The concentration of endosulfan is estimated to be 280 µg/l if everything ends up in the field water. A mean value of the concentration of endosulfan detected in the field water 50 days after spraying was 0.7 µg/l. A total of endosulfan, 0.03 µg/l was detected in filter sample 11 from Field 6.

280 – 0.7 = **279.3 µg/l** was estimated to be degraded/dissipated from the field after 50 days.

A similar scenario occurs on Field 7 where 261 µg/l is estimated to “disappear” from the field in just 8 days (Appendix XIII). It seems that there is a faster degradation/dissipated on Field 7 or that more particles are bound to sediments due to the very muddy water. The age of the rice can have an impact of the degradation of pesticides, but in this case was the age similar with a rice age of 50 and 47 days for Field 6 respective 7. The same rice type (*Capirona*) was also cultivated on the two fields. It is known that there is a fast degradation of endosulfan on plant surfaces. The doses and mixing of pesticides between the fields are similar where both field use approximately 180 l of water per ha and 0.375 l and 0.4 1 of *Thiodan* per ha. As shown in Table 14 is endosulfan slightly degradable in soil with a range of 60-800 days. The degradation rate in water is also very variable, but increases with higher pH. The water on the field has a pH that varies between 6-8.

The estimations of 280 µg/l of endosulfan on the field after spraying can be compared to the EQS for surface water in the European Framework for water that has a limit of 0.004 µg/l.

6.6.2.2 Estimates of degradation of alpha-cypermethrin

Application of alpha-cypermethrin on Field 6 (2.5 ha) 14 June 2005

Two barrels filled with a total of 360 l water are used

Sampling: 14 June, i.e., directly after spraying and 5.6 mm of rain

Fastac: $C_{1(\text{alpha-cypermetrin})}$=100 g/l, $V_{1(\text{alpha-cypermethrin})}$ = 0.5 l

$C_{2(\text{alpha-cypermethrin})}$ = The new concentration in the barrel, $V_{2(\text{volume water + pesticide})}$ = 360 l + 4 l

$C_1V_1 = C_2V_2 \rightarrow 100$ g/l * 0.5 l = C_2 * 364 l
C_2 = 0.137 g/l

Estimated height of water on the field: 5 cm

Volume water on 2.5 ha field=2500 dm * 1000 m * 0.5 dm = 1250000 dm^3

$C_1V_1 = C_2V_2 \rightarrow 0.137$ g/l * 364 l = C_2 * 1250000 l

Concentration of alpha-cypermethrin in the field right after spraying,
C_2 = 0.0000400 g/l = 40 µg/l

The concentration of alpha-cypermethrin is estimated to be 40 µg/l if everything ends up in the field water. In water sample 11 was 3.1 µg/l detected and the filter sample of the same sample was 2.4 µg/l detected. These results can be compared to the Swedish Standard Criteria for alpha-cypermethrin in surface water that is 0.001 µg/l (Table 21).

6.6.2.3 Estimates of the concentration of methamidophos directly after spraying

Application of methamidophos on Field 6 (2.5 ha) 14 June 2005

Two barrels filled with a total of 360 l water are used

Sampling: 14 June, directly after application and 5.6 mm of rain

Stermin: $C_{1(\text{methamidophos})}$ = 600 g/l, $V_{1(\text{methamidophos})}$ = 1.5 l

$C_{2(methamidophos)}$ = The new concentration in the barrel, $V_{2(volume\ water\ +\ pesticide)}$ = 360 l + 4 l

$C_1V_1 = C_2V_2 \rightarrow 600$ g/l * 1.5 l = C_2 * 364 l
C_2 = 2.5 g/l

Estimated height of water on the field: 5 cm

Volume water on 2.5 ha field = 2500 dm * 1000 m * 0.5 dm = 1250000 dm^3

$C_1V_1 = C_2V_2 \rightarrow 2.5$ g/l * 364l=C_2 * 1250000 l

Concentration of methamidophos in Field 6 directly after spraying,
C_2 = 0.00072 g/l = **720 µg/l**

Methamidophos is acutely toxic to larval crustaceans in 96-hour toxicity tests at concentrations of 0.00022 µg/l (Juarez et al. 1989). This can be compared with the concentration of 720 µg/l estimated in the field water.

The calculations above are just estimates and do not include degradation processes. Despite of this is a conclusion from the estimations that if the water from the field is mistakenly led out in the stream of Mishquiyacu directly after spraying it can cause huge damages in the aquatic ecosystem.

6.7 Sources of error

Because of the small number of interviews it is possible that the answers from the semi-structured interviews are somewhat misleading. However, I consider the probability of this to be small. In addition to the interviewed farmers, we were in contact with a great number of other farmers that gave us similar information, and our own observations have also been important in the study and essentially confirm the results from the interviews.

Another possible source of error can be contamination of the samples. Procedures were taken to avoid contamination, but there is always a contamination risk because of the circumstances we worked under. Most of the equipment was carefully washed with alcohol before and after use and the filtration of water took place as far away from pesticides as possible. There seems to be some kinds of contaminations that were observed when screening for carbosulfan, carbofuran and methamidophos at NILU. Other risks for contamination were during the transport to Sweden and during analysis at IMA. We were not sufficiently trained to perform this kind of sensitive analyses. At one occasion the temperature increased too much while evaporating the solvent, with a risk of analyte loss in this step. In addition, it was not possible to add surrogate standards to the samples at the time of extraction in the field. Had this been possible the recovery of the analytes in each individual sample could have been estimated more accurately.

6.8 Results from the two other studies

Gun Lange reported on the analysis of blood samples from 24 rice farmers on GC-ECD. Twenty-one different pesticides or degradation products, most of them POPs, were identified. The most abundant compound in the blood was p,p-DDE. Other detected substances were α-HCH, γ-HCH, HCB. Traces of chlorinated biphenyls (PCB) and DDT were found in many of the samples. An unknown substance detected in all the samples was identified as Pentachloroanisole (PCA) on the MS. The results of the analyzed blood samples showed that the ban of the Persistent Organic Pollutants has been successful in Peru.

A questionnaire was also distributed to different health care centers in Tarapoto. The result from this show that most of the personnel have treated patients with pesticide poisoning symptoms, but that there were a lack of professional training in their treatment (Lange 2006).

In the study performed by Agneta Andersson (2006), she concluded that the primary source of information to the farmers about the pesticide products and their use is the salesmen in the agro-stores. The salesmen have a close relation to the farmers as one of their selling strategies. Only 50% of the interviewed salesmen routinely gave safety instructions, and as stated above some vendors even recommend the use of restricted, highly toxic pesticides. Their job is to sell the agrochemicals and they do not seem to know/care about the consequences of the use. It is indicative that only one of the nine interviewed salesmen was aware of the danger of drinking milk before and after spraying, while the other salesmen seemed to recommend it. In contrast, the labelling of the pesticides containers is sufficient according to standards set by FAO. In spite of the low activity among the salesmen to inform about the risks, the study indicated that the main reason for the unsafe use of pesticides among interviewed rice farmers is not a lack of information or unawareness. The farmers are aware of how the pesticides should be used, but do not take the health or environmental problems that can arise seriously (Andersson 2006).

The interdisciplinary approach of the three studies will hopefully give a more reliable picture of the actual situation for all the parties involved and maybe show the complexity of the pesticide problem.

6.9 Comparison with other studies

When searching for similar studies has it not been easy to find reports that include the substances detected in Tarapoto. This may be due to that many of the pesticides used in Tarapoto are not manufactured for use on rice. It was also difficult to find studies of other compounds than organochlorine pesticides. The only good comparative substance found was endosulfan. Many of the compounds studied are already banned in the countries where the studies were performed and it can be questioned if the resources should be spent on substances that are not longer in use.

6.9.1 Endosulfan

Ghana

A study from Ghana (Ntow 2001) using SPE was performed to evaluate the situation of organochlorine pesticide residues in water, sediment, crops, and human fluids. The water samples were collected in streams that pass through areas of intense tomato farming. α-endosulfan was detected in 64% of the samples (n = 50) and showed the highest concentration with a mean of 0.0623 µg/l. β-Endosulfan was detected in 60% of the samples with a mean of 0.0314 µg/l. Endosulfan-sulfate had the highest find-frequency (78%), with a mean concentration of 0.0308 µg/l.

Table 24. A comparison concerning surface water samples between Ghana and Peru

Samples from surface waters	α-endosulfan (mean) µg/l	β-endosulfan (mean) µg/l	Endosulfan-sulfate (mean) µg/l
Peru (no positive samples/total)	0.006 (1/5)	0.006 (2/5)	***0.028 (3/5)***
Recovery (%)	***66***	***61***	***74***
Ghana (no positive samples/total)	0.062 (32/50)	0.031 (30/50)	0.031 (39/50)
Recovery (%)	***88***	***86***	***91***

The concentrations of α-endosulfan and β-endosulfan are around 10 times higher than in the Peruvian study while the endosulfan-sulfate is similar.

Table 25. A comparison concerning soil particles between Ghana and Peru

Sediment/soil particle samples	α-endosulfan (mean)	β-endosulfan (mean)	Endosulfan-sulfate (mean)
Peru (soil particles from filters)*	0.004 µg/l suspended particles	0.006 µg/l suspended particles	0.023 µg/l suspended particles
Ghana (sediments) (no positive samples/total)	0.19 µg/kg dry weight (40/42)	0.13 µg/kg dry weight (37/42)	0.23 µg/kg dry weight (41/42)
Recovery (%)	104	92	108

* The mean results are from pooled filter samples, were positive results were obtained from the irrigations canals and field water.

For technical reasons, the results from the filter samples are not comparable. However, it should be noted that the amounts of soil particles on the filters were very low.

Greece

A nationwide monitoring survey from Greece showed that the most commonly encountered organochlorine insecticides in Greek surface waters were endosulfans and its metabolite (Konstantinou et al. 2006). The survey included water samples from major rivers that drain major agricultural areas and lakes. In this study, the contamination of water bodies with pesticides was highest in areas with flooded rice fields. Greece is one of the big consumers of endosulfan in Europe and the result should not reflect the general situation in rivers and lakes in the European Union. Other commonly detected pesticides in the study were herbicides like atrazine, metolachlor, trifluralin, and insecticides like lindane, aldrin, and parathion-methyl. The results from this study are very similar with the results from Ghana.

Malaysia

The Selangor River in Malaysia has also been subject to investigation of pesticide contamination (Leong et al. 2007). Along the river there are many areas with agricultural activities like oil palm and rubber plantations, cultivations of vegetables and aquaculture. The river is a source of raw water to the public water supplies. Endosulfan (α and β) concentrations in the river were in the range 0.1-1.85 µg/l and endosulfan sulfate 0.0395 - 0.27 µg/l. The extremely high concentration of endosulfan during the dry season 2003 could, according to the authors, be due to leakage of pesticide storage tanks from the nearby oil palm plantations or vegetable farms. Since 1990, endosulfan has been restricted in Malaysia to palm oil and coconut plantations only (Leong et al. 2007). Other substances detected in the Selangor River were lindane, isomers of heptachlor, dieldrin, metabolites of DDT chlorpyrifos and diazinon. The results from Malaysia are almost 100 times higher than the Peruvian study except for one extreme value. It was a bit surprising that there was no detection of endosulfan sulfate at all in the samples from 2003. There was no big difference in the result of endosulfan between the dry- and the rainy season.

India

A study from India shows large similarities with the Peruvian study (Singh et al. 2007). Surface water and soil samples were collected from the Indo-Gangetic alluvial plains. The surface water passes through an area with high agricultural activity (rice, sugarcane, maize, wheat, barley etc.) and the region is known for high input of pesticides. The samples were screened for the most common organochlorine pesticides like aldrin, DDT, HCH, DDT, chlordane, endosulfan etc. In the water samples the median values of endosulfan were below the detection limit except for α-endosulfan (0.004 µg/l). The range varied between 0.07-0.13 µg/l for α-endosulfan and β-endosulfan, meanwhile endoslufan sulfate was below the detection limit. The other screened substances showed a similar pattern.

Another study performed in India concerned the ground water in the city of Hyderabad (Shukla et al. 2006). Water samples from 28 domestic wells were collected. Very high concentrations of α-endosulfan and β-endosulfan were detected with a range of 0.21-0.87 respective 1.34-2.14 µg/l. The concentrations of pesticides in the water samples were found to be above their respective Acceptable Daily Intake (ADI) values for humans. These concentrations are 100 to 1000 higher than in the Peruvian study. Other substances detected in the ground water were DDT and lindane.

Argentina

Water samples from the Jáchal and San Juan Rivers, both in an agricultural area, were screened for pesticides. The rivers are used to irrigate large fields of vegetables and wine yards. (Baudino et al. 2003). Endosulfan was detected in concentrations around

100 times higher than in the surface water in Tarapoto. Other active ingredients detected in the study were among others metabolites of DDT, HCH and heptachlor, which was the most frequently detected substance. The water samples from the Jáchal River showed the highest concentration of all in this comparison.

Another study from Argentina concerns the water from the Reconquista River (Rovedatti et al. 2001). The Reconquista River is an important tributary river to the River Plate that in turn supplies the inhabitants in Buenos Aires with drinking water. Endosulfans were included, but not detected, in the screening. This is a bit surprising as the Recongquista River passes through an agricultural zone were endosulfan probably is used. Substances detected in the study were heptachlor, chlordane and metabolites of DDT and HCH.

Jordan

Both endosulfans and its metabolite were detected in surface and groundwater in a study performed in an agriculture area in the Jordan Valley. The concentrations were similar in both types of water (Shahin 2004). The concentrations of endosulfan in the ground water beside Field 1 in the Peruvian study are 100 times higher than in the Jordan valley, except for β-endosulfan that was not detected in Peru.

Costa Rica

A study from Costa Rica found that endosulfan was detected in 92% of the samples from run-off water from agriculture. Water sampling directly from watercourses connected to rice fields in Costa Rica showed a range of endosulfan from 0.04 to 400 µg/l (IRET-UNA 2004). This value can be compared to the estimation of endosulfan from Field 6 right after spraying that had a value of 280 µg/l.

The concentrations of endosulfan in Peru are in the middle of the range of the other studies. It should be noted that water samples from the Jáchal and the San Juan Rivers in Argentina had the highest concentrations, and that the study from India did not show higher values despite the high input of pesticides in the area.

6.9.2 Butachlor

A study from Japan shows the results from the Shinano River (Tanabe et al. 2001) The Shinano Rive flows like Cumbaza River through a rice production area. In the Shinano River 53 pesticides were detected (22 herbicides, 15 insecticides, 11 fungicides and 5 metabolites). Only one of those, butachlor, was in common with the study from Tarapoto. This is another indication of that the pesticides used in Tarapoto not are produced to be used on rice.

An average of butachlor from the 4 sampling sites from the Shinano River shows a concentration of 0.032 µg/l. This value can be compared to the 3 µg/l detected in Cumbaza River that had a recovery of 26%.

Table 26. Comparison with other studies

Surface water / Substance (µg/l)	**Argentina** Conquista River	**India** Range	**Jordan** Range	**Peru** Mean	**Greece** Maximum	**Ghana** Mean	**Malaysia** Rainy season-03 Range	**Malaysia** Dry season-03 Range	**Malaysia** Rainy season-02 Range	**Argentina** San Juan River Mean	**Argentina** Jáchal River Mean
Endosulfan-α	n.d	traces-0.13	n.d-0.0003	**0.006**	0.043	0.062	see below	see below	see below	0.395	0.389
Endosulfan-β	Traces	traces-0.07	n.d-0.0002	**0.006**	0.023	0.031	see below	see below	see below	0.071	0.709
Endosulfan sulfate	n.d	traces	n.d-0.0005	**0.028**	0.028	0.038	n.d	n.d	0.0395 to 0.27	n.s	n.s
Endosulfan (α, β)							0.1-0.15	0.12-1.8	0.18-0.20		
Butachlor	n.s	n.s	n.s	**2.98**	n.s	n.s	n.s	n.s	n.s	n.s	n.s

Groundwater	**Peru** Sample 18	**Jordan** Range	**India** Hyderabad Range
Substance (µg/l)			
Endosulfan-α	**0.0014**	n.d-0.00008	1.34-2.14
Endosulfan-β	**n.d**	n.d-0.00003	0.21-0.87
Endosulfan sulfate	**0.002**	n.d-0.00005	
Surface water	**Peru**	**Japan**	
Substance (µg/l)			
Butachlor	**2.98**	0.032	

n.s not screened for
n.d not detected

7. Suggestions for the future, the situation in the study site today and concluding remarks

The benefits of using pesticides have to be revised considering the risk, both to the environment and for the health of the farmers using them. If pesticides and other agrochemicals are used in a proper way, they can be important tools to reduce hunger in the world. For some crops the use of pesticides may be essential, especially in the tropics, to get a yield the family can survive on. In the Tarapoto-region, many of problems are related to the trade and use of pesticides described above. The use of highly toxic and restricted pesticides, not even recommended for rice, is a major issue of concern. Other difficulties in Tarapoto are, e.g., inadequate management and storage, low awareness both of the consequences for the human health and the environment and about alternatives to pesticides, lack of suitable washing facilities, nonexistent first-aid provisions and proper waste management. The situation can be improved from different angels, locally, nationally and globally. Some alternatives to improve the situation are listed below.

Pesticide containers

The fate of the empty pesticide containers should be taken more seriously. Empty pesticide containers are a big problem especially in developing countries where recycling is not well developed. According to Ing. Leiva at the SENASA office in Tarapoto, SENASA is discussing this issue on a national level. One option discussed is to burry the empty pesticide bottles in the Peruvian dessert. Here, I think that the manufactures should have to take a bigger responsibility to help the consumer take care of the toxic garbage. One option can be to introduce a recycling system similar to the soda bottles. This could be a way to at least collect the bottles in one place instead of burning, burring, leaving them in the field or throw them in the irrigation canals. A first step could be organizing the collection of the empty bottles via the well-organized irrigation committees. The pesticide bottles should also contain a safety device to prevent that children can open them easily.

Integrated Pest Management

One measure to reduce the use of pesticides is integrated pest management, IPM. IPM contains different practices like natural predators, use of manual labour, minimizing the doses etc. One of the most important elements in IPM is training of farmers in its use.

Implementations of different techniques instead of/or together with the pesticides is the main issue. According to all the interviewed farmers in this study there was no need to apply pesticides or fertilizer at all, the first years of rice cultivation. If pesticide use is reduced, natural enemies to the pests may come back. The recommended application doses on the pesticide containers are not specialized for rice in many cases. This indicates that many of the pesticides used in the study site are not even recommended for rice by the manufacturers. In this case I think the salesmen in the agro-stores should have a greater responsibility and legislation should be stricter. It should not be possibly to sell restricted pesticides like methamidophos to rice farmers.

In addition, alternative cultivation methods may be used to complement the methods used today. The SICA-method was developed during the 80´s and has showed good results in the rice cultivation. In this method, the seedlings are transplanted at an earlier stage of their development than normally used. The seedlings are transplanted one by one and with a bigger distance in between. Herbicides are not used within this method, but it demands more manual work. Other advantages are that a smaller amount of seeds and less water are needed (Asociación de Promoción y Desarrollo Agrario et al. 2007-05-23).

INIA has also developed a method with decreased spraying frequency. This method is based on spraying of fipronil in the almácigo. The applied pesticide will protect the rice until 30 days after transplantation. Due to the less frequent spraying will this method reduce the risk for the farmers and also be more beneficial for the environment. The spraying of only the almácigo is easier to perform and it is also cheaper than to spray the whole field (INIA 2005). Although questions have been raised concerning the use of fipronil, as it is a broad spectrum pesticide classified by WHO as Moderately hazardous and very toxic for some birds, fish and invertebrates.

The introduction of organic production of rice in the area may be difficult due to the high abundance of pests in the tropics.

Changing of crops

The deficit of water makes it hard to defend the cultivation of rice in Tarapoto. A re-implementation of traditional crops like cassava, beans etc. in an agroforestry- system would probably save water and also improve the nutrition among the population.

Biobeds

Introduction of biobeds can be a tool to diminish pesticide residues in water sources. A so-called biobed is a Swedish invention that consists of a hole in the ground containing a mixture of topsoil, peat mould and straw. The aim is to retain spilled pesticides and decompose them in the biobed. The straw material is the most important component as it is on this material the white rot fungi (*Phanerochaete chrysosporium*) is found. These fungi can decompose different kinds of chemical substances including pesticides. For a good degradation of pesticides is it important that the fungus have optimal conditions in the biobed (Castillo et al. 2000). The size of a biobed can vary, in Sweden for example are they mainly constructed for tractors where the farmers can fill and wash the spraying equipment. The technique can bee adapted to small-scale agriculture system in developing countries due to the easy construction and where materials in the surroundings can be used. I think it would be a good idea to introduce biobeds along some rice fields in the study area where the farmers can mix, charge and wash their sprayers. Information about how the biobed works and god maintenance are must to receive good results.

Models and monitoring

Very toxic substances are flowing in over the Peruvian borders, but Peru has little capacity to analyse complex samples and detect unwanted chemicals. Peru needs more certified laboratories where it is possible to perform trace determination of pesticides. Until laboratories with possibilities to quantify pesticides can be developed and environmental monitoring start, modelling may be a reasonable tool to estimate the risk of contamination of the area with individual pesticides. However, much research is needed to calibrate a model before it can be used.

Politically

Taxation options should be considered. Research by economist David Yangen concludes that a tax on all pesticides would improve farmer health, but reduce profitability (Yangen 2005). A tax on only high toxic pesticides would improve both farmer health and profitability. Both a better control of the agro-stores and an improvement of the rice production practices are needed. It seems that many rice farmers do not even know that the *cabrilla* since May 2005 is forbidden. A synchronized seeding and harvest is desirable, but in my opinion can it be very difficult to carry out it practice. There is not enough machinery or day-paid workers to rent or pay if all the rice farmers in a region harvest at the same time. It would also be difficult for the mills to take care of the big amounts of rice. Possibly, the price on rice would decrease during this time as well.

Strong lobbying should take place in the legislatures of the countries that manufacture highly toxic pesticides. It should not be possible to produce or export pesticides that are forbidden in the manufacturing country itself. In the European Union, the new European Chemicals regulation adopted in December 2006, REACH, may have a positive effect in the struggle to increase the responsibilities of the manufacturers. In addition, the aggressive marketing of highly toxic pesticides that occurs, especially in the developing countries, must stop!

It is not sufficient that the big agrochemical companies are trying to better their image by donating money to finance, e.g., nature conservation, water protection, schools, against children labour, organizing seminars and training for farmers in developing countries. This is just a way to decrease the bad conscience of the other activities that are going on and give the company a better name. In my opinion is it like if the tobacco industry would support the healthcare to fight lung cancer.

The companies that really follow the Code of Conduct should be rewarded for this. Certification of products from companies that follows the CoC is one alternative, another is a certification system of the produce that will indicate that pesticides classified Ia and Ib are not used in the production.

The situation at the study site today

The results of the three studies were presented at a meeting of the Comitée of Rosanayco 11 June 2006 (Photo 20). Approximately 80 rice farmers were present. Owners and sellers from 12 stores that sell pesticides were invited personally and in writing, but none of them showed up. The meeting got positive response among the participants.

Two of the interviewed farmers do not cultivate rice anymore. One has replaced the rice with corn and plantains; the other one has opened an Internet café while another farmer leases his field. One mother would not let his son work as a peón after the results from the blood sampling had been reported.

Photo 20. Presentation of the interdisciplinary-study, June 11, 2006

Other problems have grown since the study was performed in 2005. There is a concern that guerrilla groups are on the move down the river Huallaga again, and the region has been severely affected by natural catastrophes like drought, flooding and earth quakes. The extreme climate is of increasing concern. In the beginning of 2007, large areas of agricultural land down the Huallaga River and River Mayo were inundated. Distribution of food from the WFP to populations was necessary and was still taken place in June 2007. The inundation has increased the price of rice temporarily. In March the same year the Cumbaza River dried up totally.

RAAA is working to implement a new law concerning the pesticides classified as Ia and Ib within “Proyecto de reglamento de la ley N^{o} 28217”. The legal action to get justice in the Tauccamarca case is continuing. When the tragedy in Tauccamarca took place the village was left with many promises that almost 8 years after have not been accomplished. Today the living conditions in the village are the same and there is still no health care centre or telephone. Unfortunately, I think we would have had a totally different picture if this had happened to children in one of the private schools in Lima and not to poor small farmers in the countryside.

This is only a pilot study but there are some improvements that could have been done in this study as well. Future efforts according to the sampling and analyses would have been to add surrogate standards in the field. The samples would also preferable been analysed in a certified laboratory by trained laboratory assistants, and with the possibility to verify substances on MS. The financial situation did not allow this. Unfortunately the number of this kind of studies in developing countries is limited in spite of the large quantities of very toxic pesticides used.
Soil samples from Field 2 and Field 6 were collected on depths of 10 and 20 cm in June 2006. Soil samples from two control spots were also collected. The samples have been transported to Sweden and are stored in a freezer for further analysis if foundations are found. A test of the activity of micro-organisms on these samples was performed in the laboratory at U.N.S.M in June 2006 but without any clear pattern.

Concluding remarks

It is clear that there is an abuse of highly hazardous pesticides in the Tarapoto region. The farmers use the pesticides available even if these are not appropriate for their living conditions or environment. The cost to the society due to pesticide contamination is hard to estimate. In my opinion, the focus should be on improvements instead of investigating the problems again with more water sampling. Difficulties must be solved with interdisciplinary work. It seems as if it is easier to get funding to "hunt for concentrations" rather than to implement possible improvements like biobeds.

If RAAA succeeds in the implementation of law N^0 28217, there is a chance to achieve improvements concerning the very hazardous pesticides. Finding a solution to the constant contamination of River Cumbaza needs urgent attention. The city of Tarapoto is growing with a higher water demand as a result, while the amount of water in the rivers and streams are decreasing. To increase the water quality a water treatment plant should be build or other methods like sedimentation basins introduced. In that case there should be a treatment plant with an incorporation of activated carbon to be able to remove pesticides residues (Leong 2007). I cannot see that the cultivation of rice has any future in the region. Presumably, water availability will be more and more problematic with time, why the monocultures of rice should be replaced by other types of agriculture.

8. Acknowledgements

It can be reasonable to question the aim of travelling all over the world to investigate the use of pesticides on rice fields when a part of the problem starts in Europe. For example is it still possible, within the European Union, to produce and export pesticides that are banned in the union itself to small farmers in developing countries. Despite of this I'm so pleased that I got the opportunity to learn more and see the consequences of the use and trade of pesticides from different angels.

I'm very grateful to all the Peruvian institutions, organisations and persons who participated and helped us in one or another way during our research, without you this report would never exist; thank you for your support, time, and patience. There are no good words for my appreciation... but I will try…

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Ing. Carlos Leiva and Ing. Andrés Sixto at SENASA, Tarapoto, Peru (2005-07-12)
Ing. Cesar Chappa Santa Maria CEDISA, RAAA, Tarapoto, Peru
Economist David Yangen at CIP, Lima, Peru (2005-04-29)

Appendix I

Original interviewform used in the semistructed-interviews

Fecha:

Entrevista con campesino arrocero

Nombre:
Sexo:
Edad:
Grado de instrucción:
Familia:
Distrito:

Sketchmap

Palabras claves: QUE? CUANDO? DÓNDE? QUÍEN? PORQUÉ? COMÓ?

* **”**Edificios” casa?, garage?, vehiculos? baño/sanidad?, agua?, electricidad?, basurero/residuos?

- Viven familias en los alrededores de los terrenos de arroz?
- Se encuentran escuelas cercanas?

* Campos de cultivos

- Tipo de cultivos?
- Número de ha?

* Fuentes de agua

- Que tipo? (pozo, rio, lago, canales)
- Que uso? pesca? riego? animales? consumo humano? lavar ropa? Canales de riego?
- Canal principal? Canal secundaria?
- De dónde viene el agua?
- Usa agua subterraneo?

* Calles/caminos
* Guardario de pesticidas/mochila

- Quien tiene acceso, responsibilidad del lugar?
- Conoce Ud. el tipo de suelo de su campo?
- Ha observado animales silvestres en o cerca de su campo de cultivo?
- Que tipo y con que frecuencia?

Fieldsketchmap

- Dueño
- Quien/quienes es el dueño de los campos cultivados?
- Que tipo de arroz cultivan?

*Los campos
- Como estan los campos distrubuidos?
- Que tiempo de crecimiento?

* Trabajo
- Quien trabaja en el campo el dueño/peónes/familiares/amgios?

* Riego
- Que tipo?
- Fluidos (ingresa/sale)? Constante?
- De dónde viene el agua?
- Cuantó se usa? (m^3)
- Diferentes cantidades dependiente del estadio del arroz?
- Se paga por el agua? Cuantó? Acceso todo el año?
- Se usa el agua del riego por otras cosas tambien(lavar, tomar etc)

* Siembra
- Tipo de siembra?
- Uso de maquinarias?

* Mantienemiento
- Fertilizantes? Que tipo?

- Adherentes? Que tipo?

*Costos/ganancias de producción?
- Costos? Ganancias?

*Problemas de plagas
- Que?tipos de plagas y cuando?
- Como se hace para eliminarlos?

***Fumigación**

*Cuando?

*****Preparación
- Que tipos de plaugicidas usan?
- Nombres?

- Fungicidas:

- Insecticidas:

- Herbicidas:

- Quien prepara los pesticidas y dónde?
- Como se hace?
- Se mezclan mas de un tipo de pesticidas?
- Que cantidad (cucharitas/mochila o mochilas/ha)?
- Tipo de envase y volumen?
- Lee la etiqueta del pesticidas antes de su manipulación?
- Considera las dosis recomendadas de aplicación?
- Frecuencia de uso(veces/campaña)?
- Realiza una evaluación previa del campo antes de la aplicación?
- Que observa?
- Respeta el periodo de carencia (periodo entre la ultima aplicación de un plaugicida y la
- cosecha en el cultivo?
- Sì no lo hace porque no?
- Quien fumiga y como aprendió?
- Tipo de mochila?
- Se usa equipo de protección
- mascarilla?guantes?Botas de jebe?Camisa manga larga?
- Algún plástico que cubra alguna parte del cuerpo cuando aplica?
- Por que no usa?
- Ha participado de alguna capitación sobre los peligros del uso de plaugicidas y sus efectos?
- Quien lo organizó (Empresas de agroquímicos?, Agencia Agraria?, SENASA?, junta de usuarios? etc)
- Aplica en dirección de viento?
- Comes o bebes cuando fumiga?

***Despues fumigación**

- Quien lava la mochila despues de la aplicación y donde?
- Que hace con los sobrantes de pesticidas?
- Que hace con la ropa de fumigación?
- Quien lava la ropa?
- La ropa utlizada en la aplicación lo lava separada a la ropa de la casa?
- Usa la misma ropa siempre cuando fumiga?
- Se baña con agua y jabón todo el cuerpo?

*Como piensa Ud. que los pesticidas affecta el ambiente? salud?

***Salud**

- Ha tenido algúnas símtomas de intoxicación?
- Cuales? (Mareos?, Dolor de cabeza?, Diareea?, Visión borrosa?, Náuseas? Dolores en el
- cuerpo?etc)
- Cuandó?
- Que hizo despues?
- A dónde acude para su tratamiento?
- Cuantó tiempo de recuperación?
- Que tipo de plaugicida?

***Envases de plaguidas**

- Que hace con el envase de plaugicidas?
- Reutiliza? agua/alimentos? se llena con otros pesticidas?
- Se junta con los residuos de la casa?Deja en el campo?Quema en el campo?entierra en el suelo? Arroja en canales de riego?

Timeline

- <u>Cuando</u> llegó a este lugar?
- <u>Porque</u>?
- Cuantos años se dedica a la agricultura?
- Cuantós años se dedica cultivando arroz?
- Miembro de algún comité?
- Cuál?

* <u>Cambios</u> de dueños y terrenos durante el tiempo?

- Alquilan?
- Ha comprado o vendido terrenos?

* <u>Eventos importantes</u> en su vida? Negativos? Positivos? niños?muertos? Formación del comité? 2002 (sequia en la costa)? Agua? Electricidad?

* <u>Cambios de cultivos</u>?

- Que? Porque?
- Cuando? Como?

- <u>Introducción</u> de fertilizantes/maquinarias/pesticidas?

Seasonal calender

- **Símbolos**

*Siembra
*Cosecha
*Meses de sol
*Meses de lluvia (menos riego?)
*Plagas
*Fumigación (insecticidas, herbicidas, fungicidas?)
*Vacaciones? *Peónes?

Dayclock -2 días

Día normal de trabajo

*Hora de levantar?

- Desayuno?

*<u>Trabajo</u>

- Que hace?
- Dónde?

- Con quién?

- Almuerzo?
- Dónde? Que?
- Con quien?

*Cuantás horas de trabajo?
*Otras actividades despues el trabajo?

*Cena?
- Dónde? Que?
- Con quién?

*Hora de acostarse?

Día de fumigación

*Hora de levantar?
- Desayuno?

*<u>Fumigación</u>
- Con quién?
- Cuantó dura?
- Dónde?

* Almuerzo? Dónde? Que? Con quien?
- Se lavan las manos antes de comer?
- Dónde?

*Cuantás horas de fumigación durante el día?
*Despues de la aplicación de plaugicidas que actividad realiza?
*Cena? Dónde? Que? Con quién?
*Hora de acostarse?
- Se sienten más cansado comparado con un día normal de trabajo?

Appendix II

English translation of interviewform used in the semistructed-interviews

Date:

Interview with rice farmer

Name:
Sex:
Age:
Education:
Family:
District:

Sketchmap

Key words: WHAT? WHEN? WHERE? WHO? WHY? HOW?

*"Buildings" house?, garage?, vehicles?, bathroom/sanitary?, water?, electricity?, garbage/residues?

- Are there any families living close to the fields?
- Are there any schools close to the fields?

* Field with crops
- Kind of crop?
- Number of ha?

* Water sources
- What kind of water source? (well, river, lake, irrigation canal)
- What purpose for use? fishing? irrigation? animals? consumption? Washing clothes?
- Principle canal? Secondary canal?
- Where does the water come from?
- Use of groundwater?

* Roads/paths
* Storage space/room for pesticides/backpack sprayers
- Who has access, is responsible for the storage space?

*Do you know the soil type of your field?
- Have you observed wild animals in or close to your field?
- What kind of animal and with what frequency?

Fieldsketchmap

- Owner
- Who is the owner of the field?

- What kind of rice are you cultivating?

*The fields
- How are the fields distributed?
- What age of the crop cultivated?

* Work
- Who is working on the field? The owner/peónes/members of the family/friends?

* Irrigation
- What kind of irrigation?
- Flow of water (inlet/outlet)? Constantly?
- Where does the water come from?
- How much water is used? (m^3)
- Different amounts of water depending of the rice age?
- Do you pay for the water? How much? Access to water during the whole year?
- Do you use the irrigation water to other things? (washing, drinking etc.)

* Sowing
- What kind of sowing?
- Use of machinery?

* Maintenance
- Fertilizers? What kind?

- Adherents? What kind?

*Costs/profits of the production?
- Costs? Profits?

*Problems with pests
- What kind of pests and when?
- How do you do to eliminate the pests?

***Spraying of pesticides**

*When?

***Preparation**

- What kind of pesticides are you using?
- Names?

- Fungicides:

- Insecticides:

- Herbicides:

- Who prepares the pesticides and where?
- How do you prepare the pesticides?
- Do you mix the pesticides with each other?
- Which amount is used? (spoons/backpack sprayers or backpack sprayer/ha)?
- What kind of bottles and volumes?
- Do you read the label of the bottle before preparation?
- Do you consider the recommended application doses?
- Frequency of application (applications/cultivation season)?
- Do you make an inventory of the field before application of pesticides?
- What do you observe?
- Do you respect the time limit during application? (the time between the last application and the harvest)
- If not, why?
- Who is spraying the field and how did the person learn to spray?
- What kind of backpack sprayer is used?

- <u>Use of protective equipment</u>
- Facemask? gloves? rubber boots? long/short legged/sleeved trousers/shirts?
- Use of any piece of plastic that cover any part of the body during application?
- If not, why?
- Have you participated in any seminar concerning the risk of using pesticides and its effects?
- Who did organize it? (Companies? Agro-stores? SENASA? Irrigation committee? etc)
- How is the application done relative to the wind direction?
- Do you eat or drink anything during the application?

***After application of pesticides**

- Who wash the backpack sprayer after application and where is it done?
- What do you do with the leftovers of pesticides?
- What do you do with the clothes after application?
- Who is washing the clothes? Are the clothes used during application washed separately from the other clothes?
- Are the same clothes always used when application taking place?
- Do you wash the whole body with water and soap after application?

* How do you think the pesticides effects the environment? Health?

***Health**

- Have you ever had symptoms of intoxication due to pesticides?
- Which symptoms? (dizziness?, headache?, diarrhoea?, blurry vision?, nauseas? body pain? etc)
- When?
- What did you do afterwards?
- Where did you go to get treatment?
- How long time for recuperation?
- What kind of pesticides caused it?

*Pesticide bottles
- What do you do with the empty pesticides bottles?
- Re-use? Use for water/food? Fill them with other pesticides?
- Gather together with the garbage from the household? Leave in the field? Burn in the field? Bury in the ground? Throw in the irrigation canals?

Timeline
- When did you move to Tarapoto?
- Why?
- For how many years have you been a farmer?
- For how many years have you been cultivated rice?
- Are you a member of any irrigation committee?
- Which committee?

* Changes of owners and land during time?
- Hiring of land?
- Have you bought or sold any piece of land?

* Important events on the life? Negatives? Positives? Children? Bereavement? Committee? 2002 (drought at the cost)? Water? Electricity?

* Changes of crops?
- What crop? Why?
- When? How?

- Introduction of fertilizers/machineries/pesticides?

Seasonal calendar

- **Symbols**

*Sowing
*Harvest
*Months with strong sun
*Months with much rain (less irrigation?)
*Pests
*Spraying of pesticides (insecticides, herbicides, fungicides?)
*Vacations? *Peónes?

Day-clock -2 days

A normal day of work
*Time of waken up in the morning?
- Breakfast?

*Work
- What are you doing?
- Where?
- With whom?

*Lunch?
Where? What? With whom?
* How many hours of work?
*Other activities after work?

*Dinner?
Where? What? With whom?
*Time of going to bed?

Day including spraying of pesticides

*Time of waken up in the morning?

- Breakfast?

*<u>Spraying</u>

- With whom?
- How long time of spraying?
- Where?

*Lunch?
Where? What? With whom?

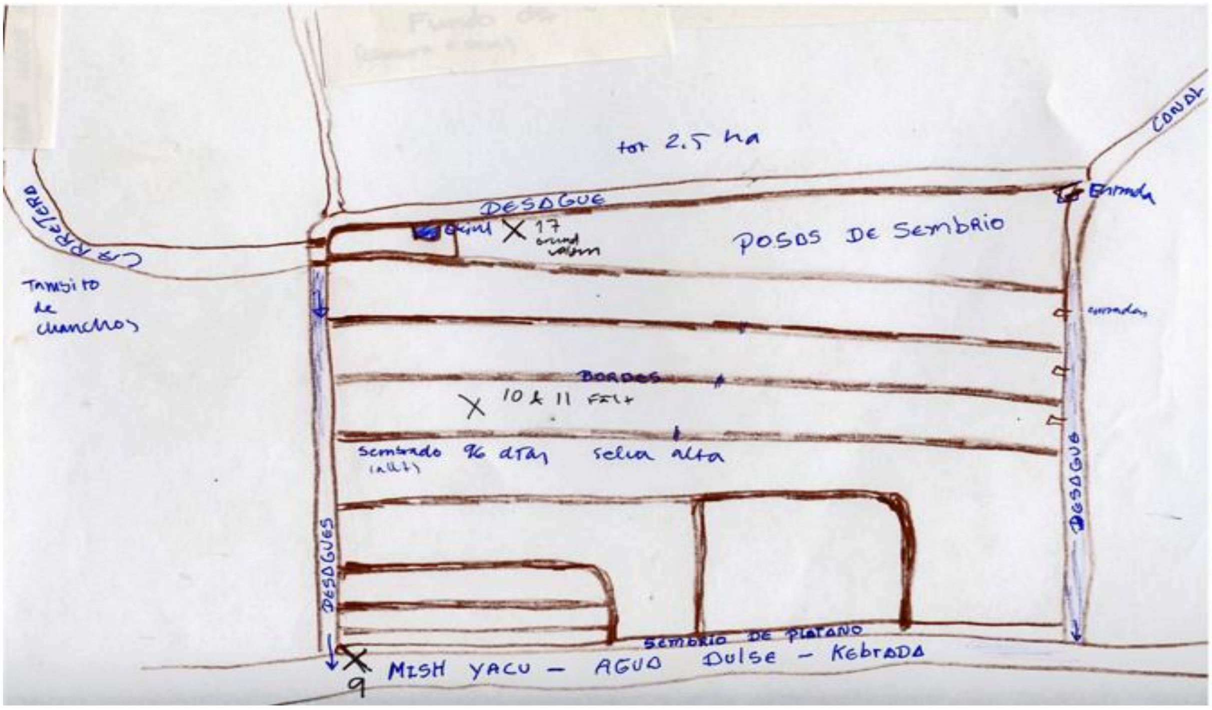
- Do you wash the hands before eating?
- Where?

*How many hours of spraying during the day?
*What are you doing after spraying?
*Dinner?
Where? What? With whom?
*Time of going to bed?

- Do you feel more tired compared with a normal day of work?

Appendix III

Examples of a sketch map and a seasonal calendar from one of the semi-structured interviews



A sketch map of a field made by a rice farmer

A seasonal calendar according to a farmer

Appendix IV

Inventory of the pesticides used by the farmers in the rice cultivation in Morales and Cacatachi, Tarapoto-region, San Martín, Peru. Commercial name and active ingredient

The inventory is based on interviews; where the farmers told us what kind of pesticides they use and on observations; pesticides we found in the field. In total there are 61 pesticides brands and 31 active ingredients used (14 Fungicide brands with 10 a.i., 28 insecticide brands with 13 a.i., and 19 herbicide brands with 8 a.i). In the inventory there are 14 pesticide brands, six of which are among the most commonly used, containing six active ingredients that are classified as Ia or Ib.

The most commonly used pesticides

Fungicides

Commercial name	**Active ingredient / CAS**	**Fungicide class**	**Classification WHO/**Human health Hazard* ***(ADI mg/kg b.w.)***	**Log P (log K_{OW})**	**LD_{50} mg/kg (oral for rat)**
Azufrac	Sulphur/7704-34-9	Multie-site inorganic	**U**/Not registered *(No data)*	Practically insoluble in water	>5000
Top Cop	Copper Sulfate/1333-22-8	Multie-site inorganic	**II**/Not found *(No data)*	Hardly soluble in water and organic solvents	100
Antracol Invento	***Propineb*** **/12701-83-9**	Multi-site alkylenebis (dithiocarbamate)	**U**/Non registered *(0.007)*	-0.26	>5000
Escudo Dithane M-45 Manzate	Mancozeb/**8018-01-7**	Multi-site alkylenebis (dithiocarbamate)	**U**/Recognized: carcinogen Susp. endocrine disruptor, immunotoxicant, skin or sense organ toxicant *(0.05)*	0.26	>5000
Fordazim	Carbendazim/**10605-21-7**	Benzimidazole	**U**/Susp. carcinogen, endocrine toxicant, neurotoxicant, respiratory toxicant *(0.03)*	1.38	6400
Fuji-one 40	***Isoprothiolane/*****50512-35-1**	Dithiolane	**III**/Not registered *(No value)*	3.3	1190
Hinosan	Edifenphos/**17109-49-8**	Phosphorothiolate	**Ib**/Not registered *(0.003)*	3.38	100-260

Silvacur	Tebuconazole + triadimenol	Triazole	**III/**Tebucanazole suspected carcinogen /Triadimenol susp. carcinogen, endocrine toxicant, neurotoxicant *(0.05)*	No figure found	>2000[3]
Folicur Orius	Tebuconazole/ 107534-96-3	Triazole	III/Suspected carcinogen *(0.03)*	3.7	4000
Score	Difenoconazole/**119446-68-3**	Triazole	**III/**Susp. carcinogen *(0.01)*	4.4	1453

Insecticides

Commercial name	**Active ingredient / CAS**	**Insecticide class**	**Classification WHO** /Human health Hazard***** ***(ADI mg/kg b.w.)***	**Log P (Log K_{OW})**	**LD_{50} mg/kg (oral)**
Carbodan ***Curater*** ***Furadan***	Carbofuran/**1563-66-2, 1563-38-8**	Carbamate	**Ia** alt**. Ib** depending on the concentration/ Susp. gastrointestinal or liver toxicant, immunotoxicant, neurotoxicant, reproductive toxicant skin or sense organ toxicant *(0.002)*	1.52	8
Marshal	Carbosulfan/**55285-14-8**	Carbamate	**Ib** /Not registered *(0.01)*	5.4	250
Thiodan Star 3	***Endosulfan*/115-29-7**	Cyclodiene	**Ib** alt. **II** depending on the concentration/Susp gastrointestinal or liver toxicant, immunotoxicant, neurotoxicant, reproductive toxicant, skin or sense organ toxicant, kidney toxicant, respiratory toxicant, cardiovascular or blood toxicant, endocrine disruptor *(0.006)*	α-=4.74 β-=4.79	70
Caporal 540 EC	Cypermethrin + methamidophos	Combination	**Ib** alt. **II** depending on the concentration *(No data)*	Depending on the formula	Depending on the formula
Rescate	Acetamiprid/**135410-20-7**	Neonicotinoid	Not listed/Not found *(0.066)*	0.8	217
Cigaral Confidor ***Lancer***	Imidacloprid/**138261-41-3**	Neonicotinoid	**II**/Not found *(0.06)*	0.57	450
Actara	Thiamethoxam/**153719-**	Neonicotinoid	**III**[4]/Susp. carcinogen	-0.13	1563

[3] The information for this fungicide is taken from the Homepage of Bayer www.bayercropscience-ca.comn since it is a mixture of two active ingredients
[4] This Classification was taken from *The Pesticide Manual*

	23-4		*(No value)*		
Metasac Monitor ***Tamaron*** ***Stermin*** Matador ***S-kemata***	Methamidophos/**10265-92-6**	Organophosphate	**Ia** alt. **Ib** dependening on the concentration /Susp. neurotoxicant, skin or sense organ toxicant, *(0.004)*	-0.8	15.6
Cypercor Fastac	Alpha-cypermethrin /**67375-30-8**	Pyrethroid	**II**/Susp. carcinogen, endocrine toxicant, neurotoxicant, immunotoxicant, gastrointestinal or liver toxicant, reproductive toxicant *(0.02)*	6.94	57
Affly Sherpa Corcell ***Hortrin*** ***Cipermex***	Cypermethrin/ **52315-07-8**	Pyrethroid	**II**/Pot. cancerogenic *(0.05)*	6.6	250-4150
Baytroid	Cyfluthrin/**68359-37-5**	Pyrethroid	**II**/Susp. gastrointestinal or liver toxicant, neurotoxicant, kidney toxicant, reproductive toxicant *(0.02)*	6.0	500
Berlmark	Fenvalerate/**51630-58-1**	Pyrethroid	**II**/Susp. Gastrointestinal or liver toxicant, Immunotoxicant, neurotoxicant, skin or sense organ toxicant, cardiovascular or blood toxicant, endocrine toxicant *(0.02)*	5.01	451
Hortiquim	Permethrin/ **52645-53-1**	Pyrethroid	**II**/Susp. carcinogen gastrointestinal or liver toxicant, neurotoxicant, reproductive toxicant, endocrine disruptor *(0.05)*	6.01	430-4000

Herbicides

Commercial name	**Active ingredient / CAS**	**Herbicide class**	**Classification WHO** /Human health hazard***** ***(ADI mg/kg b.w.)***	**Log P (Log K_{OW})**	**LD_{50} mg/kg (oral)**
Hachazo ***Machete*** ***Chem-Rice***	Butachlor /**23184-66-9**	Chloroacetamide	**U**/Susp. carcinogen *(No Data)*	4.5[5]	2000
Arsenal	Imazapyr/**81334-34-1**	Imidazolinone	**U**/Not registered *(No data)*	0.11	>5000
Hedonal Sanamina	***2,4-D/ 94-75-7***	Phenoxy acid	**II**/Susp.carcinogen, gastrointestinal or liver	2.58-2.83	639-764

[5] This data was not found in the Pesticide Manual and hence the information was found in the SRC Physpropdatabase http://esc.syrres.com/interkow/webprop.exe?CAS=23184-66-9

Aminacrys			toxicant, developmental toxicant, neurotoxicant, reproductive toxicant, skin or sense organ toxicant, respiratory toxicant, cardiovascular or blood toxicant, skin or sense organ toxicant *(0.01)*		
Roundup Glifonox Balazo Rango Bazuka Batalla Destructor Sikosto	***Glyphosate*/1071-83-6**	Phosphonates	**U**/Susp. cardiovascular or blood toxicant, gastrointestinal or liver toxicant, neurotoxicant, reproductive toxicant, respiratory toxicant *(0.3)*	<-3.2	5600
Nominee	***Bispyribac sodium*/125401-75-4**	Pyrimidinyloxy benzoic	**U**/Not Found *(0.011)*	-1.03	4111
Oryza	Cyclosulfamuron/**136849-15-5**	Sulfonylurea	**U**/Not found *(No data)*	1.58	>5000
Metsul	Metsulfuron methyl/**74223-64-6**	Sulfonylurea	**U**/Non registered *(0.22)*	0.018	>5000
Saturn	Bentiocarb/thiobencarb/**28249-77-6**	Thiocarbamate	**II**/Susp. Neurotoxicant *(0.009)*	3.42	1033

* The information is taken the 22nd of July 2005 and 27th of April 2006 from the webpage: http://www.scorecard.org/chemical-profiles/
This website compiles information from different databases with information about the effects of chemicals
If not otherwise stated all data are from *The pesticide Manual* Thirteenth Edition. Editor: C D S Tomlin. BCPC, Hampshire, 2003

The information is compiled by Gun Lange

Appendix V

Examples of pesticides used on the fields and the respective active ingredient. Pesticides determined in the samples are in bold

Field number	Fungicides	Herbicides	Insecticides
1	Antracol (propineb) Escudo (mancozeb) Fuji-one (isoprothiolane) Folicur (tebuconazole) Hinosan (edifenphos)	Balazo (glyphosate) Hedonal (2,4-D, phenoxy acid) **Machete (butachlor)** Nominee (bispyribac sodium) Oryza (cyclosulfamaron) Round-up (glyphosate) Saturn (bentiocarb/ Thiobencarb)	**Cipermex (alpha-cypermethrin)** **Furadan (carbofuran)** Hortrin (cypermethrin) Sherpa (cypermethrin) **S-kemata (methamidophos)** **Star-3 (endosulfan)** **Stermin (methamidophos)** **Tamaron (methamidophos)** **Thiodan (endosulfan)**
Detected active ingredients in samples associated to the field		Butachlor	endosulfan (α-, β-, and -sulfate) methamidophos carbofuran carbosulfan
2	Antracol (propineb) Fuji-one (isoprothiolane) Folicur (tebuconazole) Fordazim (carbendazim/ benzimidasole)	**Machete (butachlor)** Round-up (glyphosate)	Affly (cypermethrin) **Cipermex (alpha-cypermethrin)** **Curater (carbofuran)** **Furadan (carbofuran)** Lancer (imidakloprid) **Monitor (methamidophos)** Sherpa (cypermethrin) **Stermin (methamidophos)** **Tamaron (methamidophos)** **Thiodan (endosulfan)**
Detected active ingredients in samples associated to the field		Butachlor	endosulfan (α-, β-, and -sulfate) methamidophos carbofuran carbosulfan
3	Antracol (propineb) Fuji-one (isoprothiolane) Folicur (tebuconazole) Hinosan (edifenphos)	Arsenal (imazapyr) Hedonal (2,4-D, phenoxy acid) **Machete (butachlor)** Nominee (bispyribac sodium) Oryza (cyclosulfamaron) Round-up (glyphosate)	**Furadan (carbofuran)** **Curater (carbofuran)** **Cipermex (alpha-cypermethrin)** Sherpa (cypermethrin) S-kemata (methamidophos) **Stermin (methamidophos)** **Tamaron (methamidophos)** **Thiodan (endosulfan)**
Detected active ingredients in samples associated to the field		-	DDE-p,p
4	Antracol (propineb)	Hedonal (2,4-D, phenoxy acid) **Machete (butachlor)**	**Curater(carbofuran)** **Furadan (carbofuran)**

Field number	Fungicides	Herbicides	Insecticides
		Nominee (bispyribac sodium) Round-up (glyphosate)	**Stermin (methamidophos)** **Tamaron (methamidophos)**
Detected active ingredients in samples associated to the field		Butachlor	parathion-ethyl DDT-o,p DDT-p,p DDD-p,p methamidophos carbofuran carbosulfan
5	Antracol (propineb) Folicur (tebuconazole) Top cop (copper sulfate)	Hedonal (2,4-D, phenoxy acid) **Machete (butachlor)** Nominee (bispyribac sodium) Rango (glyphosate) Round-up (glyphosate)	**Cipermex (alpha-cypermethrin)** **Curater (carbofuran)** **Furadan (carbofuran)** Lancer (imidakloprid) Sherpa (cypermethrin) **Stermin (methamidophos)** **Tamaron (methamidophos)** **Thiodan (endosulfan)**
Detected active ingredients in samples associated to the field		-	endosulfan (β- and -sulfate) methamidophos carbofuran carbosulfan
6	Antracol (propineb) Fuji-one (isoprothiolane) Folicur (tebuconazole) Fordazim (carbendazim/ benzimidasole) Silvacur (tebuconazole+ triademinol)	Hedonal (2,4-D, phenoxy acid) **Machete (butachlor)** Nominee (bispyribac sodium) Round-up (glyphosate)	Cigaral (imidacloprid) **Cipermex (alpha-cypermethrin)** **Fastac (alpha-cypermethrin)** Lancer (imidacloprid) **Marshal (carbosulfan)** Sherpa (cypermethrin) **Stermin (methamidophos)** **Tamaron (methamidophos)** **Thiodan (endosulfan)**
Detected active ingredients in samples associated to the field		Butachlor	endosulfan (α-,β- and -sulfate) parathion-ethyl alpha-cypermethrin methamidophos carbofuran carbosulfan
7	Antracol (propineb) Fuji-one (isoprothiolane) Folicur (tebuconazole)	Aminacrys (2,4-D, phenoxycarboxylc acid) Bazuca (glyphosate) Hedonal (2,4-D, phenoxycarboxylc acid) Metsul (metsulforon) Oryza (cyclosulfamaron) Round-up (glyphosate) Saturn (bentiocarb/ Thiobencarb)	**Cipermex (alpha-cypermethrin)** **Cypercor (alpha-cypermethrin)** **Furadan (carbofuran)** **Tamaron (methamidophos)** **Thiodan (endosulfan)**
Detected active ingredients in samples associated to the field			endosulfan (β- and -sulfate) methamidophos carbofuran carbosulfan

Appendix VI

Information about the sampling sites

Water from irrigation canals

Sample number	Date of sampling	Water connections of sampling site	Depth of sampling (cm)	Amount of water filtrated through SPE cartridge (ml)	Observation/information
2	2005-06-02	Sub lateral 12 Field 1	20	250	• Latest rain: 4.0 mm 1/6-05 • Muddy stationary water • A couple of dead foxes have been found in the area
3	2005-06-03	Sub lateral 16 Field 4	5-10	740	• Latest rain: 4.0 mm 1/6-05 • Stationary water • Tadpoles and algae • Close to a house
4	2005-06-03	Sub lateral 16 Field 4	10-15	570	• Much of the water comes from other fields • Slow flowing water
5	2005-06-03	Sub lateral 16 outlet from Field 4	5-10	350	• Stationary water • Tadpoles and algae
6	2005-06-10	At the end of sub lateral 16 Field 7	40	380	• Latest rain: 6.4 mm 5/6-05 • Second last field before outlet in Cumbaza • Problems with saturation due to the location of the field • The age of the water is 10 days. When the principle canal is intact there is constantly water in the irrigation canals around the field • Stationary water
7	2005-06-10	Sub lateral 16 (outlet) Field 7	50	250	• Very muddy stationary water • The age of the water is 10 days • A frog
13	2005-06-16	Sub lateral 16 Field 5	20	460	• Latest rain: 14.5 mm 14/6-05 0.4 mm 15/6-05 • Slow flow of muddy water
14	2005-06-16	Sub lateral 16 (outlet) Field 5	2	350	• The water is also used for washing household equipment • Slow flow of water • Low pressure during filtration • algae
16	2005-07-14	Sub lateral 15 Field 3	15	1250	• Latest rain: 1.8 mm 6/7-05 9.4 mm 7/7-05 • The first irrigation water from Cumbaza River since 15 days • Sampling from the surface of flowing water
19	2005-07-27	Principle canal (before lateral 12)	77	700	• Latest rain: 5.1 mm 26/7-05 • The velocity is calculated to

					around 1.75 m/s • Flow: 1.9-2 m^3/s • 100 m before the sampling spot is the wastewater from the village of Cacatachi let out in the canal (treated in 3 sediment basins before)
22	2005-08-02	Sub lateral 14 Field 2	30	1315	• Latest rain: 5.1 mm 26/7-05 • Flowing clear water • Close to the principle canal • Water from many irrigated fields
23	2005-08-02	Sub lateral 14 (outlet) Field 2	20	1530	• Outlet that also irrigates the field beside • Slow flowing water

Surface water

Sample number	Date of sampling	Sampling site	Depth of watercourse (cm)	Amount of water filtrated through SPE cartridge (ml)	Observations/Information
1	2005-06-02	Huascachaca	30	930	• Latest rain: 4.0 mm 1/6-05 • Outlet and inlet for an unknown numbers of rice fields • ~1 m wide • Flowing muddy water • Empty bottles of pesticides found in the water
9	2005-06-14	Mishquiyacu	40	350	• Latest rain: 1 mm 11/6-05 • Outlet and inlet for an unknown numbers of rice fields • ~3 m wide • Flowing muddy water
12	2005-06-16	Codo seco	40-50	890	• Latest rain: 14.5 mm 14/6-05, 0.4 mm 15/6-05 • Outlet and inlet for an unknown numbers of rice fields • ~1 m wide • Slow flowing muddy water
21	2005-07-30	Cumbaza Boca Toma (before the start of the principal irrigation canal)	100 Sampling depth 60	7994	• Latest rain: 5.1 mm, 26/7-05 • Clear flowing water • Stony bottom • Composite sample • ~8 m wide • 2 filters needed
24	2005-08-02	Cumbaza Santa Rosa de Cumbaza (downstream the study site)	7-25 Sampling depth10-15	2868	• Latest rain: 5.1 mm, 26/7-05 • The final outlet for most of the rice fields in the area and untreated wastewater from Morales and Tarapoto • Stony bottom covered with green/black algae • 15-20 m wide • Very dirty water with signs of faeces and waste products from a slaughterhouse • Signs of eutrophication • Small fishes next to the riverbank and dead tadpoles • 7 filters needed

Groundwater

Sample number	Date of sampling	Sampling site	Depth of sampling from land surface (cm)	Amount of water filtrated through SPE cartridge (ml)	Observations/information
15	2005-07-13	Field 3, closest sub lateral is 15	70 and 100	4400	• Latest rain: 9.4 mm 7/7-05 • Composite water sample from two corners in the rice field • The field has 20 cm high plant residues of rice • Big cracks on the soil surface • Precipitation of iron and a mottled zone which indicates a periodic saturation • 3 filter needed
17	2005-07-23	Next to field 6, nearest waters are the stream of Mishquiyacu and sub lateral 15	130	6420	• Latest rain: 18 mm 18/7-05 • Pesticides are mixed close to the sampling spot and also an outlet from another field • The age of the rice on the field next to is 139 days • Significant amount of organic material in the first horizon • 4 filter needed
18	2005-07-27	Next to field 1, closest sub lateral 13	70	6538	• Latest rain: 5.1 mm 26/7-05 • A more sandy soil than the other groundwater samples • Close to the sampling spot there is a farm with a well that uses the water as drinking water • 3 filter needed

Water from fields

Sample number	Date of sampling	Sampling site	Depth of sampling (cm)	Amount of water filtrated through SPE cartridge (ml)	Observations/Information
8	2005-06-10	Field 7, close to the end of lateral 16	15-20	285	• Latest rain: 6.4 mm 5/6-05 (heavy rain) • The field is in the end of the field chain and has sometimes problems with saturation • Very muddy water that first was filtered through a net
10	2005-06-14	Field 6, close to lateral 15 and the stream of Mishquiyacu	5	338	• Latest rain: 7.6 mm in the morning 14/6-05 • Sampling just before spraying and rain • The field has sometimes problems with saturation
11	2005-06-14	Field 6, close to lateral 15 and the stream of Mishquiyacu	5	310	• Sampling after 40 minutes of rain, 5.6 mm, and spraying with tebuconazole, carbendazim/benzamidasole, methamidophos and cypermethrin
20	2005-07-30	Field 1, almácigo, outlet to sublateral 12	2-7cm	820	• Latest rain: 5.1 mm 26/7-05 • 750 m^2 and 120 kg seeds of Capirona

Appendix VII

Results from the water samples

I= Irrigation canal, F=Field water, S=surface water, Al=almácigo

Sample	α-endosulfan (µg/l)
23I	0.23
22I	0.21
10F	0.073
24S	0.006
18G	0.0014
Sample	**β-endosulfan (µg/l)**
10F	0.17
22I	0.095
23I	0.080
7I	0.045
8F	0.028
11F	0.024
2I	0.010
12S	0.006
1S	0.003
19I	0.003
Sample	**Endosulfan-sulfate (µg/l)**
8F	0.75
10F	0.71
11F	0.50
7I	0.13
6I	0.049
12S	0.047
23I	0.027
2I	0.021
9S	0.021
22I	0.021
14I	0.020
1S	0.015
13I	0.011
24S	0.010
20Al	0.008
19I	0.003
18G	0.002
Sample	**Alpha-cypermethrin (µg/l)**
11F	3.1

Sample	Σendosulfan (µg/l)
10F	0.96
8F	0.77
11F	0.52
23I	0.34
22I	0.32
7I	0.17
12S	0.053
2I	0.031
1S	0.020
19I	0.010
24S	0.007
18G	0.0034

Sample	Butachlor (µg/l)
9S	3.0
3I	0.12
24S	0.078
1S	0.076
22I	0.052
23I	0.034
19I	0.025
20Al	0.020

Sample	Paration-ethyl (µg/l)
9S	0.063
4I	0.024

Sample	DDT-o,p (µg/l)
3I	0.006
Sample	**DDD-p,p (µg/l)**
3I	0.004
Sample	**DDE-p,p (µg/l)**
16I	0.003

Appendix VIII

Results from the water samples in %

Active ingredient	% of irrigation canals containing active ingredient (n=12)	% of surface waters containing active ingredient (n=5)	% of groundwater containing active ingredient (n=3)	% of field waters containing active ingredient (n=4)	Range µg/l
α-endosulfan	17%	20%	33%	25%	0.0014-0.232
β-endosulfan	42%	40%	-	75%	0.003-0.168
Endosulfan-sulfate	67%	80%	33%	100%	0.002-0.746
Butachlor	33%	60%	-	25%[1]	0.020-2.98
Paration-ethyl	8%	20%	-	-	0.024-0.063
DDT-o,p	8%	-	-	-	0.006
DDE-p,p	8%	-	-	-	0.003
DDD-p,p	8%	-	-	-	0.004
Alpha-cypermethrin	-	-	-	25%[2]	3.138
Methamido-phos	100%	100%	100%	100%	Traces
Carbofuran	100%	100%	100%	100%	Traces
Carbosulfan	100%	100%	100%	100%	Traces

[1] Sample from the almácigo
[2] Sample 11, collected after spraying of the substance

Appendix IX

Results from the filter samples

I= Irrigation canal, F=Field water, S=surface water, Al=almácigo

Sample	α-endosulfan (µg/l)
16I+22I+23I+4I +14I+2I+13I+6I	0.007
8F+20Al	0.003
11F	0.002
Average	0.004

Sample	β-endosulfan (µg/l)
8F+20Al	0.013
16I+22I+23I+4I +14I+2I+13I+6I	0.004
11F	0.002
Average	0.006

Sample	Endosulfan-sulfate (µg/l)
8F+20Al	0.038
11F	0.024
10F	0.006
Average	0.023

Sample	Σendosulfan (µg/l)
8F+20Al	0.054
11F	0.028
16I+22I+23I+4I +14I+2I+13I+6I	0.011

Sample	Alpha-cypermethrin (µg/l)
11F	2.37
8F+20Al	0.29
1S+12S+9S	0.03

Sample	DDT-p,p (µg/l)
8F+20Al	0.012
5I	0.010

Appendix X

Water parameters from Cumbaza River and the stream of Mishquiyacu

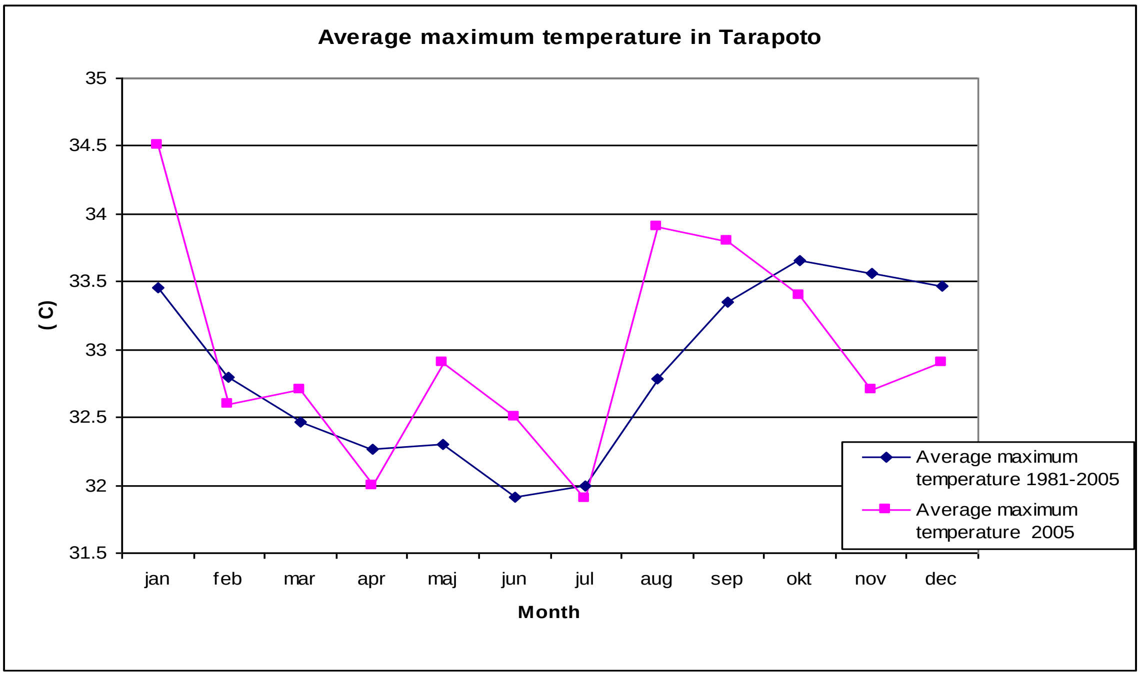
Parameters	*Cumbaza River, Puente San Antonio*	*Cumbaza River, Cacerio Juan Guerra*	*Stream of Mishquiyacu*
Year of sampling	1999	1999	1999
Temperature (°C) increasing to decreasing water level	23.0 - 26.4	30.5 - 33.0	26.5 - 28.8
pH, increasing to decreasing water level	6.5 - 9.1	6.6 - 8.8	7.5 - 7.8
Dissolved oxygen (mg/l) decreasing water level	8.4	8.5	8.0
Salinity (‰) increasing to decreasing water level	0.5 - 0.1	0.1	4.0 - 4.4
Electrical conductivity (dS/m) decreasing water level	110	400	8300
Chlorides (mg/l) decreasing water level	40	40	2400
Average velocity (m/s) increasing water level	0.8	0.34	0.86
Average velocity (m/s) decreasing water level	0.17	0.32	0.27

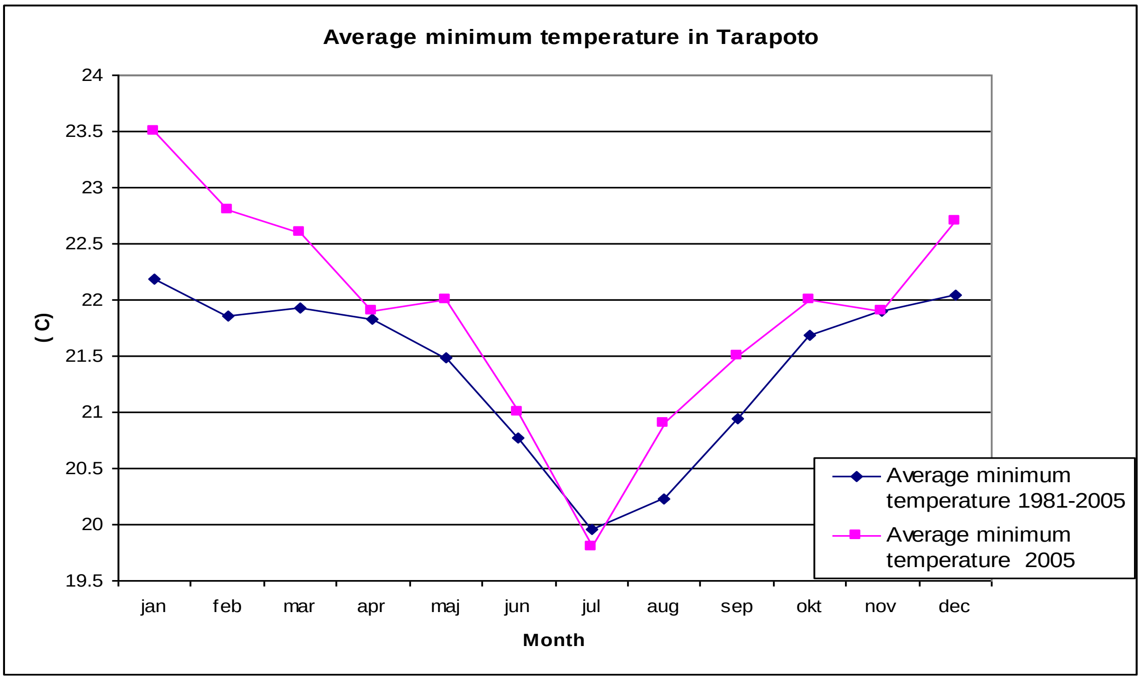
Source: Maco Hídrografía 2005

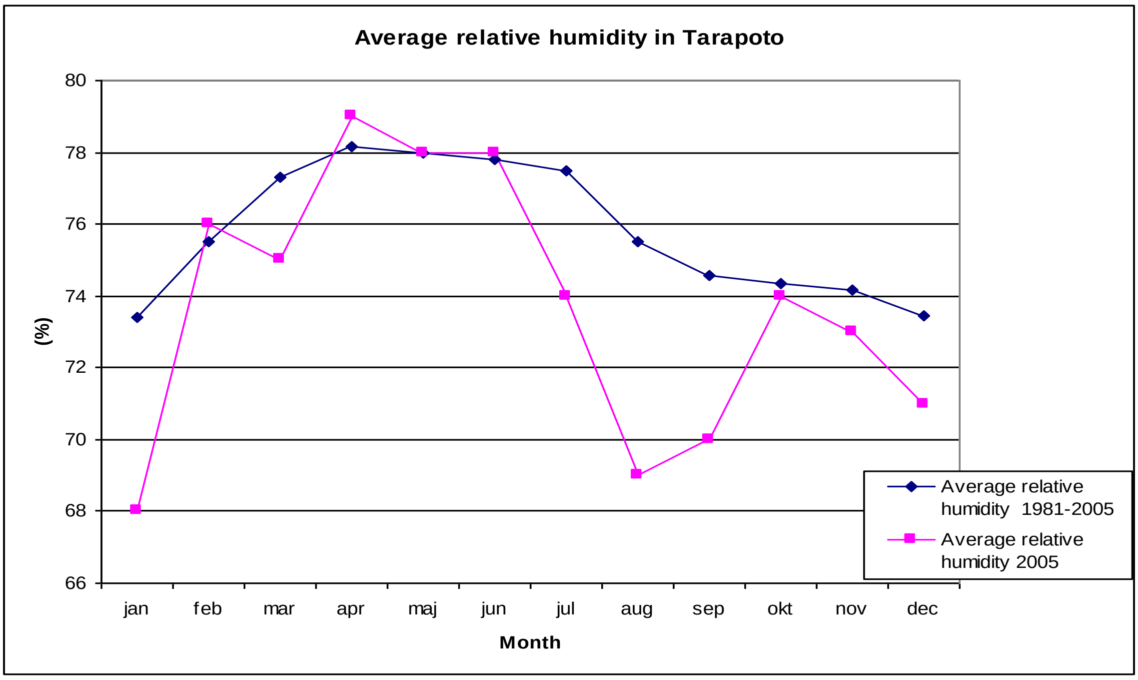
Appendix XI

Average maximum temperature, average minimum temperature, average relative humidity, sun radiation, UV dose, soil moisture and soil temperature from Tarapoto climate station

Altitude: 350 m a.s.l. Latitud: 06° 28´ S, Longitude: 76° 22´ W







Source: SENAMHI 2006

Week 2005	Date	Sun radiation (W/m^2)	UV dose (MEDs)	Soil moisture (%)	Soil temperature (C°)
21	23-29 of May	174.37	0.26	21.01	28.16
22	30 of May-5 of June	168.34	0.27	29.09	27.53
23	6-12 of June	184.68	0.28	34.41	27.82
24	13-19 of June	183.68	0.28	32.33	27.87
25	20-26 of June	167.55	0.26	14.12	27.40
26	27 of June to 3 of July	199.63	0.29	5.64	27.30
27	4-10 of July	162.00	0.24	6.79	26.89
28	11-14 of July	203.61	0.27	8.09	26.31
	Total average	180.48	0.27	18.94	27.41

Source: SENAMHI 2006

Appendix XII

Soil characteristics of Field 6 and Field 3

Soil parameters Field 6	
% Sand	30
% Clay	48
% Silt	22
P (meq/100g)	9
Mg (meq/100g)	2.8
Ca (meq/100g)	15.2
$CaCO_3$ (%)	2.3
pH	7.2
Organic material (%)	2.8
Electrical conductivity (dS/m)	1.3
Density (g/cm^3)	1.0
Texture	Clay

Soil parameters Field 3	0-5cm	10-20cm	20-50cm	50-70cm
% Sand	40	33	49	74
% Clay	48	60	40	21
% Silt	12	7	11	5
Texture	Clay	Clay	Sandy clay	Sandy loam
Density (g/cm^3)	1.25	1.28	1.35	1.43
Organic material (%)	2.8	2	1.6	1.2
Soil humidity (%)	31	27	21	20

The soil samples were analyzed by Ing. Max Pezo Perero at the soil laboratory at U.N.S.M

Appendix XIII

Estimates of degradation/dissipations of used pesticides

Estimate of degradation/dissipation of endosulfan on Field 7

Application of endosulfan (4 ha) 2 June 2005

Two barrels filled with a total of 360 l water are used

Sampling: 10 June, i.e., 8 days after spraying

Thiodan: $C_{1(endosulfan)}$ = 350 g/l, $V_{1(endosulfan)}$ = 1.5 l

The new concentration in the barrels of water
$C_{2(endosulfan)}$ = $V_{2(volume\ water\ +\ pesticide)}$ = 720 l + 2 l

$C_1V_1 = C_2V_2 \rightarrow$ 350 g/l * 1.5 l = C_2 * 722 l
C_2 = 0.727 g/l

Estimated height of water on the field: 5 cm

Volume water on 4 ha field = 4000 dm * 1000 m * 0.5 dm = 2000000 dm^3

$C_1V_1 = C_2V_2 \rightarrow$ 0.727 g/l * 722 l = C_2 * 2000000 l

Concentration of endosulfan in the field, C_2 = 0.0002625 g/l = **263 µg/l**
Concentration detected on the field: 0.774 µg/l

Amount degraded/dissipated from field: 262.5 - 0.774= **261.7 µg/l**

Estimate of degradation/dissipation of cypermethrin in the almácigo on Field 1

Spraying of 750 m^2 with cypermethrin 18 and 25 July 2005

One backpack sprayer with 15 l water is used

Sampling: 27 July, i.e., 2 respective 9 days after spraying

Hortin: $C_{1(cypermethrin)}$ = 250 g/l, $V_{1(cypermethrin)}$ = 0.02 l

$C_{2(cypermethrin)}$ = The concentration in the backpack sprayer, $V_{2(volume\ water)}$ = 15 l

$C_1V_1 = C_2V_2 \rightarrow$ 250 g/l * 0.02 l = C_2 * 15 l
C_2 = 0.333 g/l

Estimated height of water in the almácigo: 3.5 cm

Volume water in 750 m^2 almácigo = 75000 dm^3 * 0.35 dm = 26250 dm^3

$C_1V_1 = C_2V_2 \rightarrow 0.333$ g/l * 15 l = C_2 * 26250 l
Concentration of cypermethrin in the almácigo right after spraying,
C_2 = 0.0001905 g/l = **190 µg/l**

0.294 µg/l of alpha-cypermethrin from suspended materials on a pooled filter sample was detected. There are no results from the screening with cypermethrin because the results were no reliable.

Estimate of degradation/dissipation of methamidophos in the almácigo on Field 3

Usually spraying of 600 m^2 with methamidophos

One backpack sprayer with 15 l water is used

Tamaron: $C_{1(methamidophos)}$ = 600 g/l, $V_{1(methamidophos)}$ = 0.1 l

$C_{2(methamidophos)}$ = The concentration in the backpack sprayer, $V_{2(volume\ water\ )}$ = 24 l

$C_1V_1 = C_2V_2 \rightarrow 600$ g/l * 0.1 l = C_2 * 24 l
C_2 = 2.5 g/l

Estimated height of water in the almácigo: 3.5cm

Volume water in 600 m^2 almácigo=60000 dm^3 * 0.35 dm = 21000 dm^3

$C_1V_1 = C_2V_2 \rightarrow 2.5$ g/l * 24 l = C_2 * 21000 l
Concentration of methamidophos in the almácigo right after spraying,
C_2 = 0.0028571 g/l = **2857 µg/l**

Appendix XIV

Estimates of the concentration of active ingredients in the mixing barrels/backpack sprayers and in the fields/almácigos

Field	Active ingredient	C barrel (µg/l)	C in field (µg/l)
1	Endosulfan	1750000	702
2	Cypermethrin	4170	1.3
3	Cypermethrin	4170	1
	Methamidophos	2500000	600
	Endosulfan	1460000	350
	Tebuconazole	42	0.01
	Propineb	5830000	1400
	Carbofuran	5210000	1250
4	Propineb	3900000	1400
	Carbofuran	3470000	1250
5	Endosulfan	1300000	280
6	Methamidophos	2470000	720
	Alpha-cypermethrin	137000	40
	Carbendazim	137000	40
	Tebuconazole	7	0.002
	Carbosulfan	566000	164
	Carbendazim	140000	40
	Endosulfan	967000	280
	Imidacloprid	0.2	56
	Propineb	3870000	1120
7	Endosulfan	727000	263

Almácigos	Active ingredient	C backpack-sprayer (µg/l)	C in the almácigo (µg/l)
1	Cypermethrin	7	0.004
3	Methamidophos	2500000	2860

Appendix XV

Extractions, chemicals and equipment

Water extraction at IMA

1. The SPE-cartridge was eluted with 3 ml **dichloromethane** and then with 3 ml **acetone**.

2. The extract was evaporated to 1.5 ml standing in a water bath under a slow stream of air.

3. 2 ml of **cyclohexane** were added to the test tube, after which the volume was further reduced to 0.5 ml.

4. A mixture of **cyclohexane and acetone 9:1**, was added to the test tube to a total volume of 1 ml.

5. 0.5 ml of the extract was transferred to a GC-vial and the other part was stored in a freezer.

6. To each vial that was not stored in the freezer, 50 µl of the surrogate standard **HBB (**hexabromobenzene) with a concentration of 0.0669 µg/ml was added. A relation 10:1, for sample and surrogate standard was wanted giving a HBB concentration of 0.00669 µg/ml.

7. The samples were now ready to be analysed on GC-ECD together with standard solutions.

Standard solutions

8. 23 different pesticide standard solutions with varied concentrations were prepared and analyzed on GC-ECD (Appendix XVI). Carbofuran, carbosulfan and metamidophos were analysed at NILU on LC-MS.

9. With the result from the GC-ECD the different internal standards were divided into two groups, Standard solution 1 and Standard solution 2. The aim of the grouping is to prevent mistake of peak identification when different substances can have the same retention time.

10. Two middle standards, M1 and M2 were prepared with various concentrations of the internal standards. The concentrations of the different substances in the middle standards were adjusted to have a response around 500 Units to facilitate further determination of concentrations.

11. Six solutions were prepared in test tubes from the middle standards. The middle standards were diluted with **cyclohexane/acetone 9:1** as following **x1,x2, x5, x8**, and **x10**.

12. The different solutions from the test tubes were then transmitted to 12 GC-vials, 0.5 ml in each. To each vial, 50 µl of the surrogate standard HBB (hexabromobenzene) was added.

13. The internal standard solutions were now ready and analysed on GC-ECD with auto sampler over night together with the samples.

Particle extraction

1. The filter from the water filtration was put in a beaker. Some of the filters from the same water type were pooled together.

2. For the beakers with just one filter were 20 ml **acetone** and 10 ml **cyclohexane** added for the others with more than 1 filter were more of the solvents added but with the same relation.

3. The beaker was sonicated in an ultrasonic bath for 30 minutes.

4. The extract was then poured in to an E-flask.

5. 5 ml **acetone** and 20 ml **cyclohexane** were than added to the beaker with the filter and sonicated for 15 minutes more.

6. The solvent was then combined with the extract in the E-flask, dried with Na_2SO_4, filtered and then pored into another flask.

7. The extract was evaporated on rotary evaporator to a volume of approximately 0.5 ml.

8. A few drops of acetone were added to the flask and the extraction was than transferred to a test tube.

9. A small volume of cyclohexane/acetone 9:1 was added to "wash" the flask and then added to the graded test tube to a total volume of 1 ml.

10. 0.5 ml of the extract was then transferred to a GC-vial and the other part was stored in a freezer.

11. To each vial that was not stored in the freezer, 50 µl of the surrogate standard **HBB** (hexabromobenzene) with a concentration of 0.0669 µg/ml was added. A relation 10:1, for sample and surrogate standard was wanted. The concentration of HBB in the samples was therefore 0.00669 µg/ml.

12. The filter samples were than analysed on GC-ECD over night together with the same standards as for the water samples.

<u>Filters pooled together:</u>

- 1,12 and 9 (Some of the surface waters)
- 2, 4, 6, 13, 14, 16, 22 and 23 (Irrigation canals)
- 20 and 8 (Field water)

Chemicals used in Peru

All the chemicals used in Peru were bought from Cimatec S.A.C in Lima and were of pesticide grade except for the ethanol that was bought in a pharmacy in Tarapoto.

- Dichloromethane MERCK
- Methanol 99.98% MERCK
- Deionized water MERCK
- Ethanol 95%

Chemicals used in Sweden

All the solvents used at IMA were bought from LabScan (County Dublin, Eire) and of pesticide grade (PestiScan)

- Dichloromethane
- Cyclohexane
- Acetone
- Sodium sulphate (s), Merck, from IVW, Spånga, Sweden.
- Hexabromobenzene (surrogate standard, Promochem, Ulricehamn, Sweden)
- Pesticide standards (Appendix XV)

Equipment

SPE cartridges: ENV+, International Sorbent Technology, Hengoed, Mid Glamorgan, UK
Filter: Whatman GFF glass microfibre, 47 mm diameter

For most of the quantifications a gas chromatograph (Hewlett Packard 6890) with a ^{63}Ni electron capture detector was used. The column flow was 1.10, length 30m, diameter 320, film thickness 25µm and the nominal temperature was 300 °C.

Appendix XVI

Standard substances and recovery study with water from river Kolbäcksån and river Lenakyrkå

There was no possibility to calculate the recovery of alpha-cypermethrin, cypermethrin, permetrin, cyflutrin, imidacloprid, methamidophos, carbofuran, carbosulfan due to unclear peaks. The substances in **bold** were detected in the study.

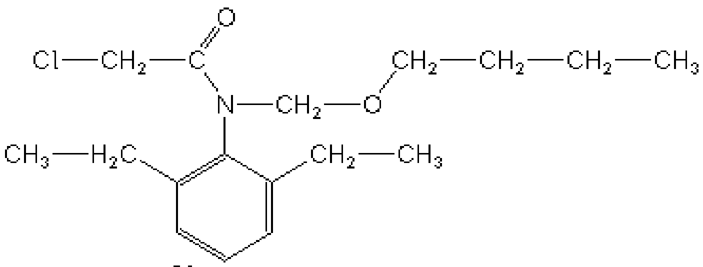
Standard solution 1 Substances 1	**Conc. 1 (ng/ml)**	**Conc. 2 (ng/ml)**	**Conc. 3 (ng/ml)**	**Average (ng/ml)**	**Recovery %**
α-HCH	0.056	0.058	0.0425	0.0522	**15.7**
β-HCH	0.1725	0.1755	0.1345	0.1608	**48.2**
Hexaclorbenzene	0.037	0.034	0.032	0.0343	**10.3**
γ-HCH	0.2765	0.187	0.2265	0.2300	**69.0**
δ-HCH	0.1785	0.1485	0.129	0.1520	**45.6**
Heptachlor	0.0175	0.014	0.019	0.0168	**5.1**
Aldrin	0.023	0.0175	0.0235	0.0213	**6.4**
Trans-heptachlorepoxid	0.091	0.0755	0.1025	0.0897	**27.0**
Clordan-γ	0.0695	0.064	0.071	0.0682	**20.5**
DDE-p.p	0.045	0.0465	0.0445	0.0453	**13.6**
DDD-p.p	0.039	0.0425	0.0375	0.0397	**11.9**
DDT-o.p	0.0105	0.011	0.011	0.0108	**3.3**
DDT-p.p	0.016	0.016	0.015	0.0157	**4.7**
Alpha-cypermethrin	Invalid	Invalid	Invalid	Invalid	Invalid
Imidacloprid	Invalid	Invalid	Invalid	Invalid	Invalid

Standard solution 1 Substances 2	**Conc. 1 (ng/ml)**	**Conc. 2 (ng/ml)**	**Conc. 3 (ng/ml)**	**Average (ng/ml)**	**Recovery %**
Paration-ethyl	0.1115	0.103	0.089	0.1012	**50.6**
α-endosulfan	0.131	0.152	0.1135	0.1322	**66.1**
Butachlor	0.0585	0.0535	0.048	0.0533	**26.7**
β-endosulfan	0.123	0.1385	0.1095	0.1237	**61.2**
Endosulfan-sulfate	0.1505	0.157	0.1385	0.1487	**74.3**
Permetrin	Invalid	Invalid	Invalid	Invalid	Invalid
Cyflutrin	Invalid	Invalid	Invalid	Invalid	Invalid
Cypermethrin	Invalid	Invalid	Invalid	Invalid	Invalid

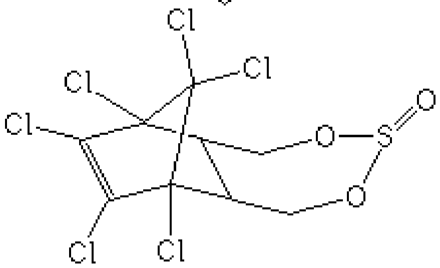
Appendix XVII

The chemical structures of the detected substances

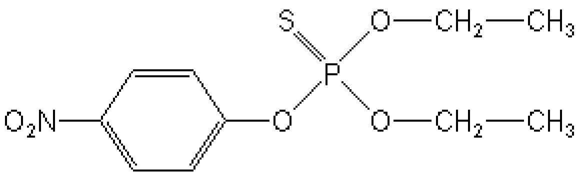
Butachlor



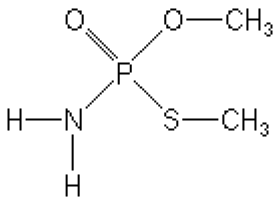
Endosulfan



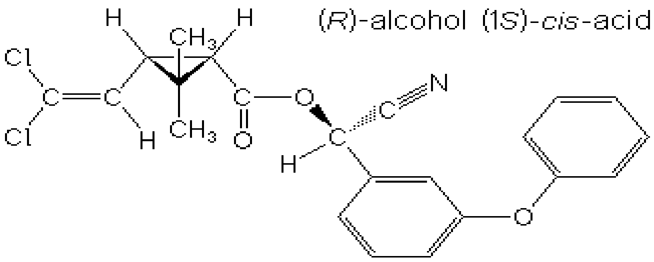
Parathion-ethyl

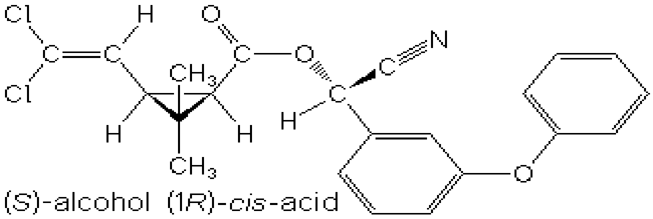


Methamidophos

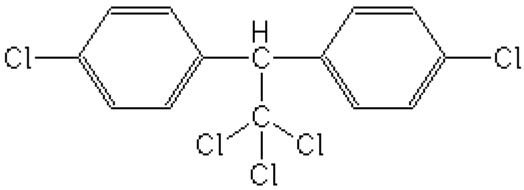


Alpha-cypermethrin

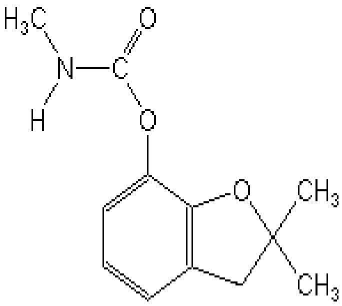


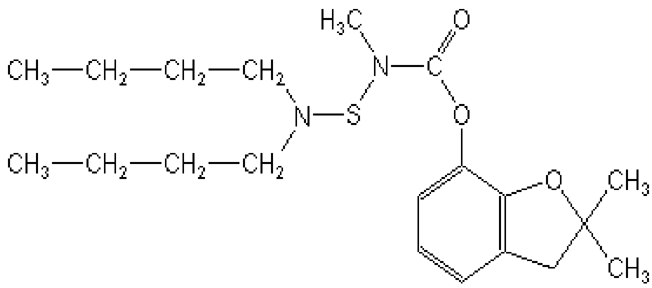


DDT



Carbofuran **Carbosulfan**





Source: The Compendium of Pesticides Common Names by Alan Wood 2007-02-22

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Usage patterns and pesticide residues in water sources

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