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Final Thesis

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SANITATION IN RURAL CHINA: WASTE MANAGEMENT AND HYGIENE MANAGEMENT IN KUNMING MUNICIPALITY, YUNNAN PROVINCE

Supervisor Senior Lecturer Eeva-Liisa Viskari
Commissioned by TAMK University of Applied Sciences
Kunming Institute of Environmental Science

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Tiivistelmä

Tutkimuksen tarkoituksena oli tutustua maaseudun sanitaatiohuoltoon Kunmingin Maakunnassa, Yunnanin Provinssissa, Kiinassa. Pienimuotoiseen tutkimukseen sisällytettiin jätehuollon, vesihuollon ja julkisen hygienian hallintatavat, pääpainon ollessa ekosanitaatiossa. Hallintapoja löydettiin useita, mutta sanitaatiohuollon tilanne maaseudulla on vielä riittämätön. Sanitaatiohuollon osa-alueissa löydettiin joko infrastruktuurin tai itse hallinnan vaihtelevia puutteita. Osa ongelmista johtuu rahoituksen puutteesta, osa keskitetystä hallinnosta ja osittain tilanne johtuu vajavaisista paikallishallinnon ”työkaluista”, toimintatavoista. Koska tutkimus toteutettiin yhteistyössä Kunming Institute of Environmental Science:n kanssa, on tutkimukseen liitetty parannus- ja yhteistyöehdotuksia tulevia opiskelijoita varten.

Miikka Ristkari

Sanitation Management in Rural China: Waste Management and Hygiene Management in Kunming Municipality, Yunnan Province
Final Thesis
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Thesis Supervisor Senior Lecturer Eeva-Liisa Viskari
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Abstract

Rural sanitation management in Chinese context is studied in Dianchi Lake catchment basin, Kunming Municipality, Yunnan Province, China. Small-scale study is conducted to find out management practices for waste management, wastewater management and public hygiene management. Varying management methods are identified, with indications being that there is a lack of management on varying aspects of sanitation in the rural areas around Kunming Municipality, partly due to financial problems of the field sites, partly because centralized coordination, best practices information and available tools for sanitation management do not exist.

Abbreviations

Organizations, entities

KIES	Kunming Institute of Environmental Science
TAMK	TAMK University of Applied Sciences
WHO	World Health Organization
KMEPB	Kunming Municipality Environmental Protection Bureau
YPEPB	Yunnan Province Environmental Protection Bureau
PLAN	Plan International, NGO

Technologies

DT	dry toilet (water is not used as a carrier)
UDDT	urine-diverting dry toilet
HSBP	Household-scale Biogas Plant

Methodologies

PHAST	Participatory Hygiene And Sanitation Transformation
CLTS	Community-Led Total Sanitation

Terms

MSW	Municipal solid waste

Currency

1 RMB	~ 0.1 €

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Foreword

This small-scale study in Kunming Municipality was aimed at investigating current situation of the management of rural and peri-urban sanitation, namely waste management, wastewater management and public hygiene management and gathering in-situ information on the challenges that face Kunming Municipality on sanitation management. The objective of the study was to use the information to formulate project ideas and suggestions on what steps might be taken to improve the situation.

The report should provide insight into sanitation management and maintenance problems in Kunming Municipality and should help identify future project ideas in the rural parts of Kunming Municipality. The study was done during 19.7. - 14.8.2007, while preparatory work was done between 20.3. - 20.6.2007. The umbrella project is a joint collaboration between Kunming Institute of Environmental Science and TAMK University of Applied Sciences, this study was done with the help of Kunming University of Science and Technology.

While I'm the sole author of this study report, there are numerous persons who have contributed to this study by either working with me, providing translations, showing locations or just discussing with me the various methods of providing sanitary services and managing public sanitation.

I would like to thank my co-workers and friends Ma Wenting and Yang Chengxi;

Marjukka Dyer, Eeva-Liisa Viskari from TAMK University of Applied Sciences; Kunming Institute of Environmental Science people Liu Shuzhi, Zhi Guoqiang, Pu Limin, Zhou Dekun, Yang Hongfu; Henry Voight from Yunnan Environmental Protection Bureau; Heinz-Peter Mang from IEEP; Wang Hongmei, Zhang Shuai and Zhang Xinyue from Kunming University of Technology and Science; and many people from Kunming Municipality. Lastly I would like to thank my wife Alena Ristkari for her patience during the 5 months I was conducting this project.

A cd with pictures of Lake Dianchi Basin rural areas can be ordered from TAMK University of Applied Sciences, Eeva-Liisa Viskari. I also suggest looking up the final theses of Yang Chenxi and Ma Wenting when they are submitted to TAMK.

Tampere, February 2008

Miikka Ristkari

1. INTRODUCTION

China is a huge country and during the last hundred years she has gone through many changes. From Qing Dynasty to republican China under Guomindang and from there on as the People's Republic of China the country has seen political upheavals and environmental calamities. However, the situation of rural population has always been poor. Modern China is moving through unprecedented economic growth, but in some cases this improvement in quality of life does not always transfer to the lower classes of population. In China, most of the rural population belongs to these lower classes.

Yunnan Province is one of the less developed provinces in China. Kunming Municipality, where this small study took place, is the development center of the Province. Also in this municipality differences in living standards become apparent in the rural areas. Environmental degradation has worsened the situation as Dianchi Lake, formerly very important to the economics of Kunming Municipality, has become increasingly eutrophicated. Starting 2005, Kunming Municipality Environmental Protection Bureau started a dry toilet construction project with primary aims being the control of rural non-point source wastewater (nutrient flow to Dianchi Lake) and improvement of rural sanitation situation. With ambitious goal of 100 000 constructed toilets till year 2007, the project has met severe setbacks and is now suspended. **Chapter 1** deals with the project more closely.
|F&R 2|

This study broadly and in many places superficially examines the whole sanitation situation in rural areas of Kunming Municipality. **Chapter 4** summaries the development of public sanitation services in the Municipality, while **chapter 8** presents the conclusions of this study – also relating to the continuity if the collaboration between TAMK University and KIES is to continue.

Chapters 5, **6** and **7** deal with specific aspects of sanitation. The information content in

each chapter varies, with wastewater management being most limited in scope – and at the same time maybe the most pressing issue. Water issues are linked with poverty and it is clearly seen in rural Kunming as well - while this document does not study poverty, it must be said that lack of clean water or adequate sanitation affects the most powerless first.

Appendix 1 can be used as a reference to Kunming Municipality – it contains various tidbits of information about the municipality, as well as pictures on some interesting topics.

Finally, **chapter 3** treats the organizational and work methods and explains how the study was conducted.

2. PROJECT BACKGROUND

This project was originally meant to be a community-involving sanitation awareness project, but due to time constraints, interest of KIES shifting from ecological sanitation to including more ecological village concepts and the type of management that was evident during field visits to dry toilet locations, it was decided by the author that studying the ways of sanitation management (and reasons to lack of it) would be more informative for future use.

Leaving the household-scale ecological toilets from the study was done deliberately, as it was deemed that there was very little value in either studying them further or trying to prototype a new, improved design. The problems in the dry toilet construction project management and the capacity building were investigated during the first three months of the project, so little could have been added with additional research. **Appendix 2** shows the small questionnaire study that was done during April 2007.

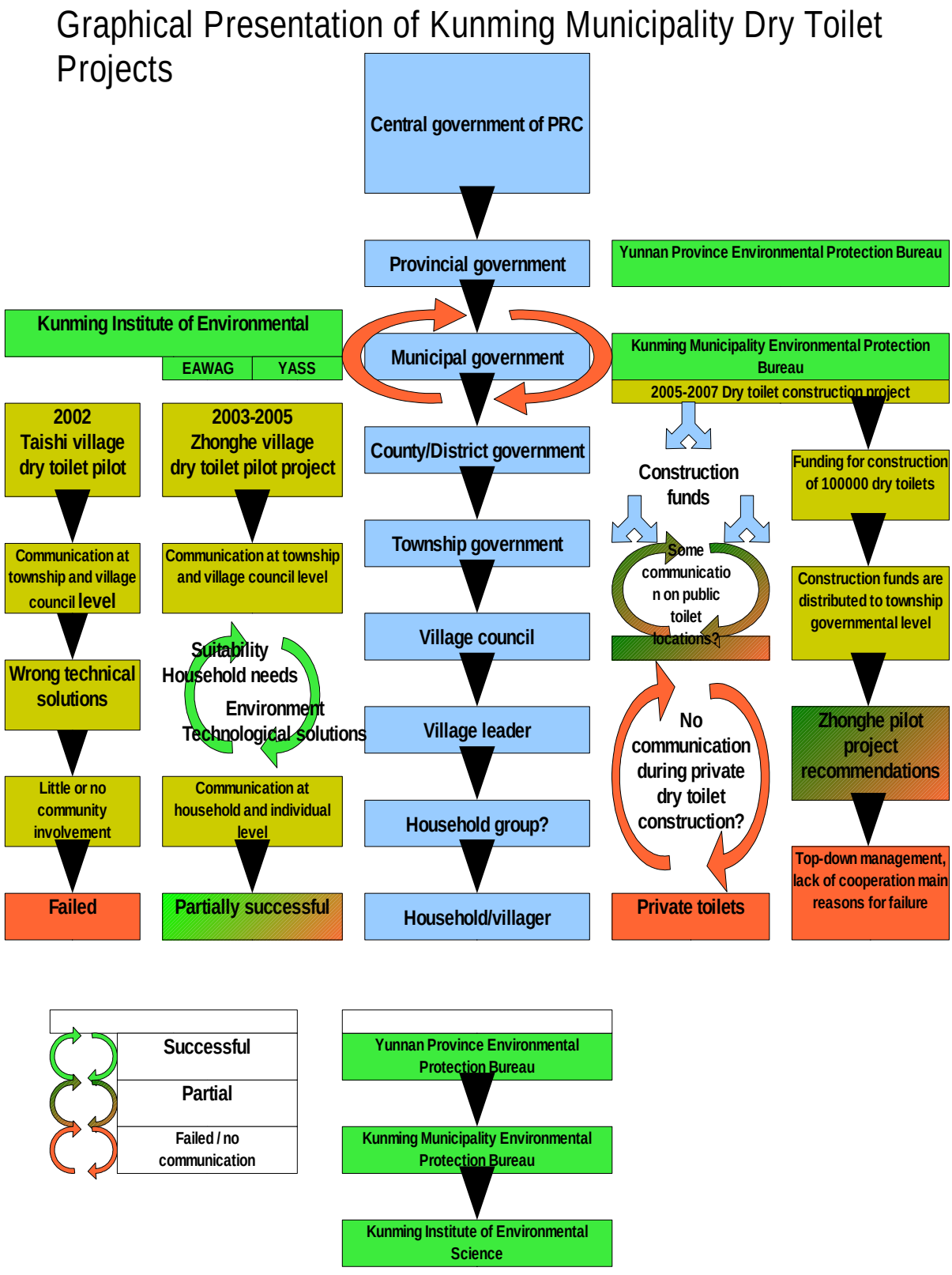


Figure 1: Kunming Municipality dry toilet projects. Miikka Ristkari 2007.

2.1. Ecological Sanitation Project Timeline

Figure 4 at page 33 explains the timeline of ecosanitation projects in Kunming Municipality. According to a project data sheet *Urine diverting toilets, Novaquatis Kunming, China* by Novaquatis and EAWAG, the first pilot project, in Taishi village on the southwestern side of lake Dianchi, was done after KIES learned of ecological sanitation from Internet. The second pilot project, in Zonghe village, was done with the help of Jui San Society that has been responsible for ecological sanitation capacity building in China, under mr. Lin Jiang. |1|

2.2.1. Future of ecological sanitation in Kunming Municipality

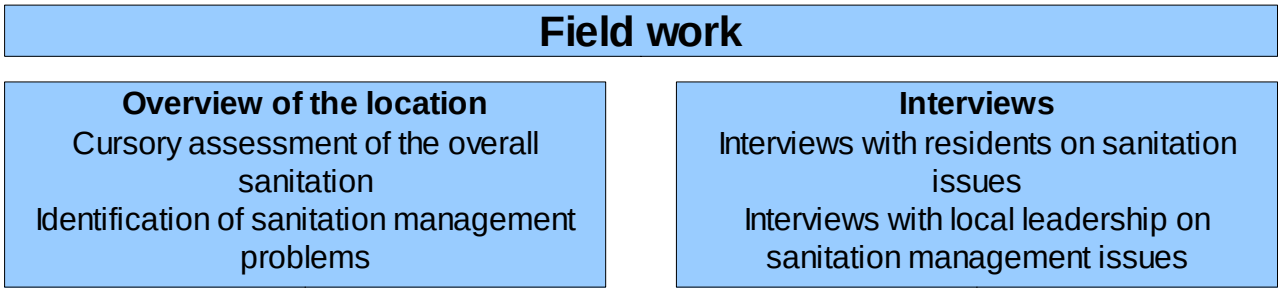
The issues that have been discussed in the beginning of this report, namely problems in management and community involvement, are evident in the dry toilet construction project. Lessons should be learned from the project. It is obvious that top-down management and huge upscaling without human resources to handle local management does not work with projects that involve local communities on sensitive issues.[1] It is possible that there are some repercussions, namely dissatisfaction and mistrust towards similar projects.

3. COOPERATION AND WORK METHODS

The research for this study was done using two methods; field work and literature study. A lot of the preparatory work was done between March and July, when Kunming Institute of Environmental Science and later we independently organized visits to villages, dry toilet sites and other project areas. The insight into Kunming Municipality was gained from these visits and allowed to select field visit locations and study objects.

1 Liu Liping in Erdos Conference on Sustainable Sanitation 2007. Available at http://www.ecosanres.org/icss/proceedings/presentations/40--LIU-Liping--EN.pdf

3.1. Field work



3.1.1. Purpose of field visits

The first purpose of the field visits was to identify sanitation management issues present in the rural and peri-urban Kunming Municipality, focus being on Dianchi Lake Basin area. The definite categories of observation were wastewater management, waste management (MSW) and public hygiene management, particularly public toilet management and maintenance.

The second purpose of the field visits was to get first-hand information from village / village group / township leaders on the problems and possibilities on respective fields of management and their opinions on the situation and how to improve it.

3.1.2. Organizing field visits

The field visits were arranged unofficially by a method best identified by Medilanski et al. (2006). No contact was made to the field visit locations beforehand, although it was envisioned this might cause problems with getting into contact with local leadership. This was done because the study group preferred to work with relative freedom, get a firsthand view to every location, and to avoid an “entourage” of the higher officials, which could have happened contact had been made with each township and village beforehand. Locations were chosen according to Dianchi Lake Basin, experiences from previous field visits and information from KIES workers and other governmental and non-governmental acquaintances.

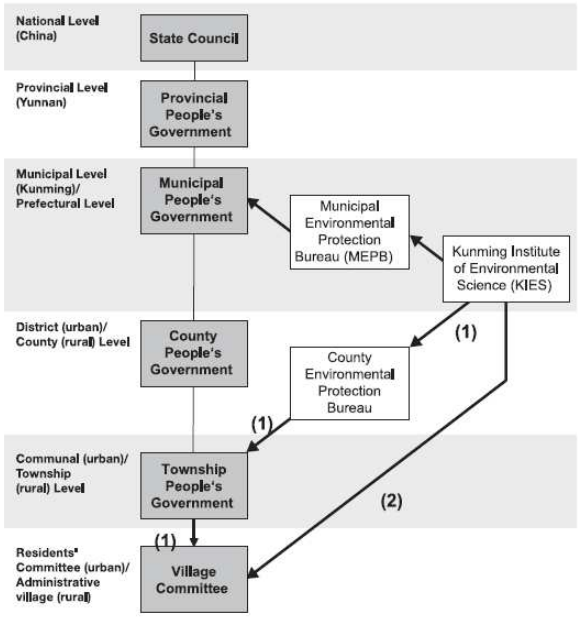


Fig. 4 Decision-making processes for the implementation of urine-separating dry toilets. The arrows (**1**) denote the strictly official pathway to get to the administrative village. In our implementation project, the village could be directly reached (**2**). See the text for a detailed description of the decision-making process

Figure 2: Decision-making processes and organizational pathways in China. Medilanski et al., "Identifying the Institutional Decision Process to Introduce Decentralized Sanitation in the City of Kunming (China)",2006.

3.1.3. Field visit locations

The field visits were arranged so that local driver picked up the Likong University students at 9.00 and the group would visit as many locations as possible in 8-9 hours. It was estimated that each location (village) would take anywhere from 1 to 3 hours, depending on how much time would be spent on interviews.

Totally 17 villages in Guandu (9), Jinning (4), Chenggong (2) and Songming (3) counties was visited. The group also visited Sanye Ecological Public Toilet company and two government projects, Dianchi Lake Biodiversity Restoration project and Dianchi Lake Wetland Restoration project. While these do not reflect in the study, they did give insight into what is happening in the restoration of Dianchi Lake, and how the municipality functions.

- Jinning County
  - 29.07.2007 Taishi village group, Taishixi and Taishi village number 4

- .08.2007 Xinjie township

- Guandu District
  - 29.07.2007 Housuo village group: Villages 1, 3 and 5, Luoya village, Yaojia village, Dingjia village, Lijia village, Sijia village.
  - 30.07.2007 Xizhuang village group, villages 3,4 and 5. Xiuying village group, village 3. Longma village.
- Cheng gong County
  - 30.07.2007 Dounan Townhip:' Shangkele village and Jiangwei village.
- Songming County
  - 9.8.2007: Shujie village group, Gucheng village.
- Bai yi County
  - 9.08.2007 Maidichong village group: Caihaukeng village

3.1.4. Field visit interviews

During field visits, open interviews with seed questions (prewritten questions used to initiate conversation and lead it during the conversation) were held to both the township and village leaders where possible. Local residents were also interviewed with questions similar to those presented to the leadership.

Figure 2: Interviewing residents of a village; Guandu District, 27.7.2007.

The interviews were done to get an overview of the sanitation situation at a given location, as well as to find out the problems and possibilities of sanitation management.

With the leadership interest lied in the management and perceived issues with the ability and feasibility of management of the various aspects of sanitation. When planning the interview moment, non-structured interview was decided to be more favorable than structured “interrogation”.

Some concerns were raised beforehand that government officials and people working in the environmental field might not be received very well, but despite this it was decided that the field team would identify themselves with the real affiliations and the purpose of the study.

The questions for the leadership were about:

1. the perceived division of responsibility of management
2. cost of management
3. current level of management
4. a question was also presented to identify the worst sanitation issue of the location and to elaborate on it

These questions were asked on each of the three main topics of sanitation, but the interviews also revolved around other issues linked to sanitation, like household income and urbanization.

The questions for village residents were:

1. to identify the perceived responsible party for sanitation management
2. willingness to participate either financially or with own work in community-scale management
3. specific questions in each sanitation category of waste, wastewater and public hygiene management
4. a question was also asked about the worst problem in the location: choices were waste management, wastewater management and public hygiene, in effect public toilets. The interviewed persons were to be asked to elaborate on the answer, to provide a clearer picture on the problem rather than just the name of the issue.

In practice the interview lengths varied quite a lot, with the local residents from 5 to 35 minutes and with the leadership from 20 to 90 minutes. This was also due to many places having several participants in the discussion, especially in the village offices. In most places the group was well received, probably partly because of the author being a foreigner, but hopefully also because sanitation clearly is a big issue in the rural and peri-urban areas and most village leaders felt powerless ("We do not have money to do waste management/ new public toilet / ditches") to change things and were willing to contribute their opinions on the issue.

3.1.4.1. Recording and translation methods

The interviews were recorded by hand in-situ in Chinese. Full transcript was not required of the assistants, but rather the relevant issues to their specific topics. The notes on the field visits and the interviews were then translated into English by the assistant students and saved in electronic format. The quality of the translations varies, as the usage of automatic translation by the assistants proved problematic. However care was taken to ensure that the most relevant issues were carefully translated.

3.2. Literature review

Second, smaller part of the study was a research for rural sanitation management literature. On-line study had been performed on subject previously, but English-language material on actual management practices in China seems to be very scarce. It was decided that a person fluent in Chinese language should conduct the review.

One day was used to briefly scan the main library of Yunnan Province and to collect references and searching for books on sanitation management. Search was then directed to topics that were interesting in context of this study. Afterwards assistant students did research individually.

3.3. Cooperation

Cooperation with Kunming University of Technology and Science was started after a discussion with the Environmental Science program headmaster in a meeting with graduating students about employment in KIES. The headmaster was enthusiastic about the project and helped contact the students and organize meetings with them.

Students Wang Hongmei, Zhang Shuai and Zhang Xinyue helped with this project.

4. PUBLIC SANITATION SERVICES

Rural sanitation situation in Kunming Municipality is summarized in following paragraphs.

The public sanitation situation around Dianchi Lake is severe, but there are strong indications that it is improving. These improvements can be attributed partly to; economic growth, international funding on sanitation and environmental protection initiatives, increased awareness of and demands from the public and finally to the actions of various levels of government in addressing both the environmental degradation of Kunming municipality and the sanitation issues themselves. |2||3||4| (Appendix 3)

However, there is a great disparity between the services offered in urban areas and rural areas. While the larger cities in Kunming Municipality are kept clean by the Kunming City Construction Management Department, the rural and semi-urban areas are suffering from inadequate wastewater and waste management, as well as poor public hygiene services. There is no coordinated effort to manage municipal solid waste in the Kunming Municipality or in the Dianchi Lake Basin. Type of management and level of sanitation services vary between counties and districts and the responsibility for management can vary from county-level Environmental Protection offices to village-level leadership.

The problematic sanitation issues vary by location. While in relatively rich Guandu area the waste management was often receiving funds, in Songming County and west Jinning County it was the most problematic issue. Chenggong County seems to be most

affected by wastewater issues due to flat terrain and lack of village-wide drainage in all field visit locations. The most common denominator for sanitation problems seems to be the economic level of the location. However, the field visit data is not enough to correlate certain sanitation issue with political or economic regions – further study and careful mapping is required. If this kind of mapping were to be done in scale, it could allow for targeted sanitation improvement projects.

Putting aside the current situation, there is a strong desire on all levels of government and population to improve the sanitation services. While the interviewed government officials mostly blamed lack of funds for poor management, ma(F&R 5)ny identified also problems with insufficient handling capacity and lack of skills in designing an efficient management system. Village leaders are interested in alternative methods of handling the issues, as long as they are cost-effective and address the problems without bringing new responsibilities for the local government. |4|

The interviewed population generally deem that the government should be responsible for management of sanitation. However, contrary to what the county-, township- and village level leadership seem to think, there are indications that management at source, and/or community involvement, would be very beneficial tools in addressing certain sanitation issues. Most of the interviewed residents were willing to either pay a small sum per year for improved sanitation, or otherwise provide for the village-scale sanitation. This has been reported already in 1996 by Yunnan Institute of Environmental sciences, but it seems that there has been no significant investments in community empowerment projects since then. |5|

5. PUBLIC HYGIENE SERVICES

The term public hygiene used here refers to public toilets and washing places. However, no public washing places were visited. During the field visits, attention was given to three details: management and maintenance, design, and overall condition of the facilities.

The state of public hygiene in the Dianchi Lake Basin peri-urban and rural areas is poor, but improves as one moves from poor villages to more prosperous areas. From modern international point of view, for example that of WHO, rural China still lacks improved sanitation, partly due to lack of facilities and partly due to differing cultural practices. Many of the rural public hygiene points, in effect public toilets, are either of insufficient design or lack management and maintenance. The on-going international and national rural improvement projects seem to be concentrated on private sanitation too, most probably because of the WHO guideline definitions. |8|

It is the author's opinion that it is worth discussion how certain development goals and definitions of sanitation levels apply to rural Kunming (and maybe to the whole of China). In particular it might be beneficial to introduce improved public facilities with good maintenance and management and adequate hygienization of excreta to the rural areas. These new public toilets could still function as part of the rural farming cycle, but with improved management and maintenance, safety of the excreta could be better ensured.
|6| |7|

5.1. Public Hygiene Management

Some villages have public hygiene facilities that are a responsibility of “no-one”. Management of village premises is the responsibility of the village leader, but they claim that the management of the public toilet facilities is not their obligation, because the toilet itself is not necessarily financed by the community, thus leading to a detachment between the ownership and usage. The public toilet management can also be “outsourced”, i.e. maintenance and cleaning responsibility is given to an outside

source. This means that management is no longer the problem of village leadership and they take no action even if the management is lacking.

While it might sound self-evident, level of management is heavily dictated by available funds, but does not necessarily correlate to better management in richer areas. Rather lack of maintenance in poorer areas can be seen clearly – although this too varies, as some villages (Taishi village as an example) have agreements where the maintenance is done without changing funds. In effect the excreta is valued so much that the farmers even pay the community for the possibility of emptying public toilets.

Many urban public toilets have a star-rating which signifies what kind of services are available from the facility. It is not feasible to extend this rating to all rural toilet facilities, but it could be implemented in simplified manner: Rural sanitation facilities could be marked with a sign specifying to who the responsibility of the facility belongs to. This way unsatisfied individuals could divert their dissatisfaction and initiate corrective measures.

This measure would not even require any specific actions to be taken on the actual management methods, but would instead rely on the public awareness to require satisfactory maintenance and management (for example cleaning of the facilities).

World Bank has an interesting project going on with public toilets titled “Management Options for Public Toilets in Liuzhou, China”. Liuzhou presides in Guanxi Province and is going through a period of intense population growth. Several management methods are presented, intended for urban public toilets. |10|

1.	**The formation of a state-owned Environment Sanitation Management Company** to carry out the functions of ESD (either separately for public toilets or encompassing both toilets and solid waste).
2.	**Contracting out toilet management** to individuals and small enterprises: an improvement over the present arrangements in that this allows clusters of public toilets to be leased.
3.	**Centralized management at the city level,** with private sector agencies as delegated toilet management contractors – in one or two sets of contracts.
4.	**Inclusion of solid waste management in the contracts**, to make public toilet management more financially attractive.
5.	**Diverse provision and management arrangements,** selecting the best fit from the above range for the specific type and revenue potential of each public toilet, while reflecting community needs and capacities.

Table 1: Management options for urban public toilets. Liuzhou, China. The World Bank 2006.

Similar system could be created to the rural areas of Dianchi Lake, to take care of the public sanitation needs of the rapidly urbanizing areas, but still retaining the overall control within the government bureaus.

5.2. Maintenance of public toilets

Poor maintenance can be taken as a sign of poor overall management, but sometimes it is a sign of lack of allocated or available funds, personnel or oversight on need of maintenance. Maintenance has profound effects on the hygienity of the facilities. Lack of proper and systematic maintenance leaves the toilets dirty and unhygienic and further promotes careless usage by community members and transient population. Unclean facilities also promote transfer of pathogens. |9|

A few different maintenance methods were identified, often related to the management of the facilities. Note that this only applies to the field visit locations – in urban areas the situation is somewhat different.

- A person or persons are hired to take care of the public hygiene facilities
- A group of persons are hired to take care of the facilities in turns (for

example consecutive days), keeping the income generated during their turn

- The facilities are cleaned by "someone" who also takes the excreta for his/her fields
- The facilities are not cleaned in any coordinated way, but cleaned when they are "too dirty" (However, answers of this kind also imply that the interviewed person did not necessarily know who is supposed to maintain the facility, but did not want to say so.)

Yearly salary of a maintenance person is 2000 RMB, which is a bit less than 2/3 of average income in Kunming Municipality rural areas. This sum is quoted by several village leaders. It is not clear whether this salary depends on how many public toilets are present in the village, but I presume that by introducing new maintenance models, the cost of maintenance could be brought down, which would improve the level or at least increase the amount of services offered.

Maintenance can only be assured if there is a person, company or other entity behind it – it should be made mandatory to have an entity in charge of maintenance of the facilities. See 3.1. Management on reflection on management.

Figure 3: Interviewing public toilet caretaker. Kunming City, Guandu District, 30.07.2007.

5.3. Design of rural public toilets

Design is a difficult issue to address for a western person due to a huge difference between European and Chinese hygiene practices and toilet cultures. There are fundamental issues though, both for hygiene and environment, that are improperly done from modern European point of view. Currently many rural toilets allow for insects and animals to come into contact with excreta, allow rainwater into the toilet facilities, do not provide privacy and do not provide hand-washing facilities. These factors all contribute to possible incidence of diarrhea and dysentery, as well as other

pathogens infecting people. |8|

These are the most important design criteria which should be changed – discussion on privacy (cubicle doors for example) should also be done, as new urban public toilets seem to have them more often than not.

Designing and constructing a a rural public toilet takes from 15 000 (traditional public dry toilet) to 20 000 (ecological, diverting public dry toilet without handwashing) to 30 000 RMB (ecological public toilet renovated to water flush toilet) according to design respectively. This price range was given by the interviewed village leaders and taken from the dry toilet construction plan, so they are not necessarily accurate market prices. In these designs, the toilets do not have cubicle doors.

While WHO does not accept public toilets into improved sanitation category (they do not offer privacy), even in public toilets there are varying levels of privacy. Most newer public toilets in Kunming Municipality rural areas lack cubicle doors, but are of an enclosed T-shape, so there is privacy against the opposing gender, but none against those of the same gender. From modern point of view this is unacceptable, and is not a huge economic issue either, considering that adding cubicle doors would increase costs by relatively small percentage, probably on the range of 5-15%. This educated guess is based on market prices of doors and workmen during the project.

5.4. Ideas for improved rural public sanitation

One project that might yield interesting results is the inspection of rural public toilets. It is possible that many older toilets are local groundwater polluters. It would also be interesting to try various improvements on the rural toilets.

- Plastic bottom lining or some cheap technique to prevent leaks to ground and groundwater
- Doors for more privacy in public toilets
- Rainwater container hand-washing devices
    - Improved hygiene through relatively cheap investment
    - No water piping required, even washing with water improves hygiene
    - Downside: seasonal rains
    - How to prevent theft / facilitate usage?
- Alternative technologies for existing public toilets could be for example composting toilets modeled after Finnish models (External container for easy transportation and emptying)

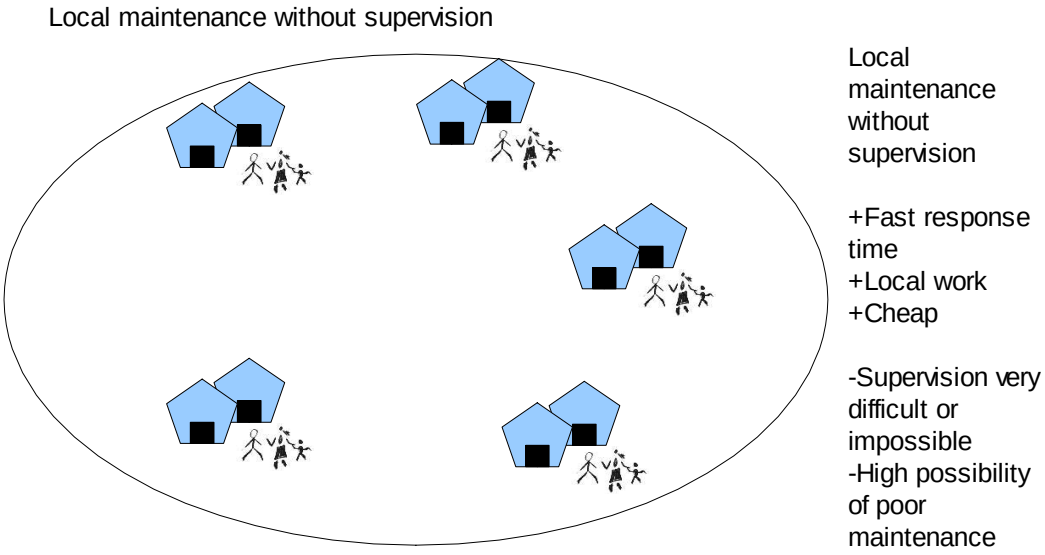
Figure 4: Public urine-diverting dry toilet. Jinning County, 6.08.2007.

Another possible project could be the facilitation of awareness campaign on separation of waste and public toilet locations. That would reduce the ”co-efficiency” of animals and flies, which might improve local sanitation conditions, especially during rainy season.

5.4.1. Maintenance models for public toilets

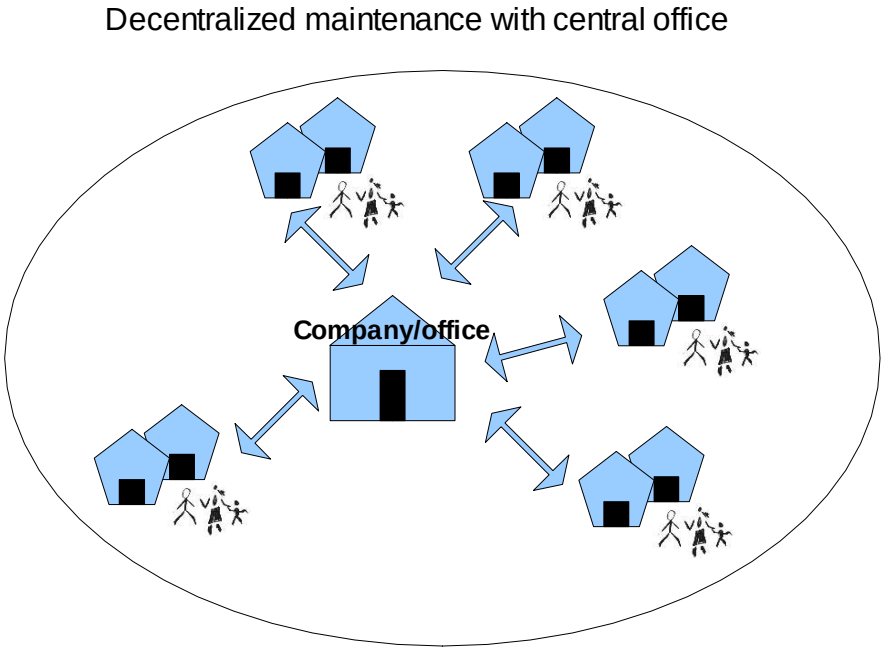
Currently the maintenance for public toilets is done locally in all of the field locations, without any centralized coordination. However, there are alternatives to this maintenance model. It should be possible to set up for example small companies or cooperatives that work especially on sanitation field. These cooperatives could ensure better maintenance and management standard and thus improved hygiene. They could

also hire staff at better salary with money earned from improved services and from for example “yearly toilet usage” payments and thus provide improved quality of life for the workers. On the downside the local employing effect would be concentrated, which would affect those people who currently have the job of facility management, usually poor and old people.

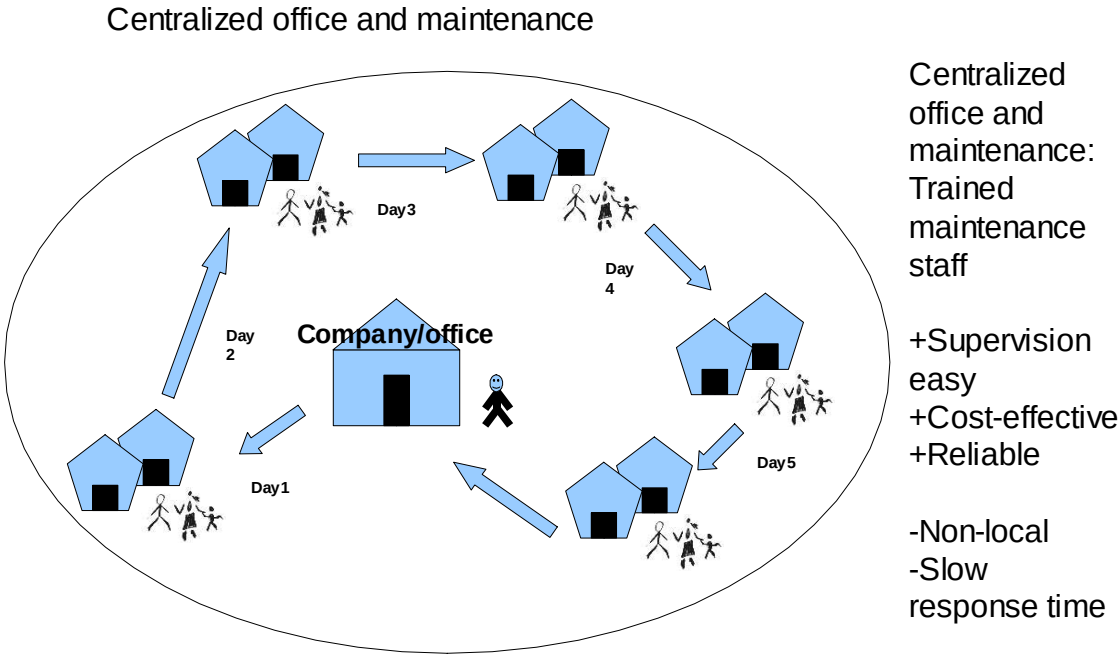


Drawing 3: Local maintenance of public toilets in Kunming Municipality.

The following two models show decentralized maintenance with central office where maintenance workers would report their doings and alternatively fully centralized maintenance arrangement, where several workers would take care of facilities in turns, servicing a larger area. Of course, the models are rudimentary at best and the economics of management and maintenance can be argued upon.



Drawing 4: Local maintenance with central management.



Drawing 5: Centralized maintenance with central management.

The point of these drawings is to emphasize the fact that different methods of operation are available even in the rural areas, especially as the Dianchi Lake Basin is densely populated and is getting more so in the near future.

6. WASTE MANAGEMENT

The waste streams around Dianchi Lake Basin can be divided into MSW, agricultural waste and industrial waste. There is no coordinated waste management, although industrial waste is covered in the environmental impact assessments that regulated industries must make. The waste management is done independently in each county/district, township and village group, although some locations cooperate. The cooperation includes for example sharing transportation or the same waste disposal site. Whereas in Europe, for example Finland, there exists infrastructure, legislation and individual mindset for separation and handling of agricultural and other waste, this is not yet the case in Kunming Municipality, except for relatively small areas or by specific ethnic groups. For example The Bai people seem to regard organic fertilizers (organic material: compost, dried plant stalks) as better and prefer them to chemical fertilizers – this should not be taken as authoritative information however. |11||14|

The management problems are quite different from European perspective, because of Kunming Municipality having agricultural and horticultural land very close to urban setting. Relatively small amounts of MSW are mixed with large amounts of agricultural by-products, especially when flowers and vegetables are harvested.

Figure 5: MSW and toilet waste together. Taishixia village, Jinning County, 25.07.2007.

The MSW that is created in households is mostly plastics, paper and biowaste. There is no concentrated sorting or separation of waste in any of the townships / villages that were visited: sometimes the farmers either dry or compost their agricultural waste to use as a fertilizer. There is a pilot project with working composting plant that collects biowaste and agricultural waste and sells it as fertilizer.

"Composting will likely take on a larger role in China. This may be driven by the value of carbon emission reductions, the fact that for the foreseeable future over 50% of the waste stream is organic, and the potential markets for finished compost (compost is effective at reducing soil erosion and degradation and helps soils retain moisture – especially important in China, where soils are highly degraded and relatively close to major cities). Clear compost quality guidelines need to be set and monitored, and specific large-scale compost use programs developed e.g. mine tailings rehabilitation and treatment of degraded soils." |12|

There is also business around recycling and reuse, cardboard, plastic and glass bottles as well as metal are readily collected from waste piles. Waste pickers work in the bigger cities and towns of Kunming Municipality and also visit villages to gather recyclables, although the interviews did not specifically point to any certain interval of visits. Without further studies, no estimates can be made of the amounts of recyclables collected this way either.

It was also evident that sometimes materials which were recyclable in the city were thrown into waste piles in the villages, which would indicate that if the amounts are very small, no value is placed on them.

Growing poverty among rural migrants in Chinese urban areas and the lack of city-wide recycling programs has led to the growth of an informal sector of waste pickers, numbering approximately 2,500,000 people. These people are most directly affected by health threats from waste as they pick through urban waste collection sites and landfills for materials that they can sell. These individuals, who usually lack any form of health coverage, are vulnerable to traffic accidents, puncture wounds, chemical burns, back injuries, and respiratory illness from particulates.* World Bank 2005

Text 1: Excerpt on waste picking in China. The World Bank, 2005. |13|

6.1. Waste management issues

In the interviews with varying government personnel, mostly local village government,

the main problems identified were related to the following issues:

1. Management skills
    1. No clear guidelines or guides exist for rural MSW management. After a literature search we found no references to rural waste management, nor did the government workers we talked to indicate that any guideline exists, at least in Kunming Municipality. This is a big issue, because the waste management of rural and peri-urban areas differs quite a lot from the city-wide waste management.
    2. As it is now, the leadership do not have access to tools that could make their waste management more economic and community- and environmentally friendly. Mr. Liu Shuzhi in KIES has written a guide for rural waste management, but apparently it is little used.
2. Economics
    1. The townships and village groups / individual villages do not have sufficient economic resources to arrange for waste management. Good waste management per village is valued at around 3000-5000 RMB per year, but none of the villages visited (except Shijia village group, Guandu) had this amount of money to use per year.
3. Landfills
    1. Kunming Municipality only has two modern landfills, Hongshuitang (Xijiao) and Baishuitang (Dong jiao), which are situated northwest and northeast of Kunming City, respectively. These landfills mainly serve Kunming City, other major urban centers and surrounding counties, but are situated too far from most of the counties to facilitate affordable transportation of waste. Especially the southern county, Jinning (field visit location), and the northern counties are located too far from the landfills. It is also doubtful whether the capacity of the landfills would be enough to support the whole population of Kunming Municipality.
4. Waste disposal facilities
    1. Those villages that have waste disposal facilities either use a small building

to store MSW until emptying, or a brick enclosure where waste is deposited until emptying. Some of the enclosures are roofed, most are not. Most villages however, especially the small and poor ones, do not have sufficient amount or any at all waste collection facilities, rather MSW is dumped where-ever convenient, or to an agreed location. Very often existing facilities are very unhygienic and unsightly.

2. When there are no proper waste disposal facilities, it enboldens community members to dump their waste where-ever they want and thus erodes the ability of waste management personnel to collect MSW.

5. Community awareness

    1. There is little or any awareness on waste handling in the communities. General consensus of the interviewed residents was that government is solely responsible for waste management.

    2. When presented with a question on whether the community members would be willing to pay a bit extra per year for better waste management, the answer was mostly yes, especially in the poorer villages that suffer the most of bad waste management. However the contribution varied from a 3 to 12 RMB per household / year.

    3. There was no awareness at all on how the individual households could impact village waste management situation by self-action, but there was an unanimous drive to change the situation to better.

6. Behavioral issues

    1. Several behavioral issues were raised during the interviews. Those villages / townships that have a lot of transient population have worse waste situation, as the transient population does not have communal awareness that would prevent them from littering. Also many residents and leaders expressed the opinion that a dirty village will only get more dirty, but a clean village would stay clean. They were of the opinion that people, also the transient population, would have second thoughts on littering a clean location.

    2. One issue was also the separation of household or private area and public place - many villages can be seen showing this mentality, as the “living

streets" are clean, but all around the "living streets" MSW is piled up. The area outside the household is considered public and the responsibility of the government, not the private person.

6.2. Recommendations and future project ideas

There is no one solution for the problems with rural waste management and Scandinavian models are too much concentrated on the input of private households to work correctly in China without extensive campaigns on awareness and mentality. However, there are many tools that can be adapted from European models into the context of rural Kunming. I recommend the following actions (and propose the following projects for next group of students) to be implemented.

6.2.1. Recommended actions

1. Create efficient guidelines and a simple but insightful guidebook containing management tools for rural waste management.
    1. The guidelines should include waste management targets on separation, recycling and acceptable landfill waste, acceptable/preferable management methods for collection, transportation and final deposit, and community responsibilities on waste management.
    2. The guidebook should provide for example economic tools to value the costs of waste management, how to arrange collection, transportation and deposit of MSW, how to facilitate separation of biowaste from other MSW, how to coordinate waste management with other entities and how to outsource waste management to private parties. It should also include acceptable designs and locations for waste collection points.
2. Facilitate separation of biowaste and agricultural/ horticultural waste from other MSW. Facilitate village collection points for commonly recyclable items like glass and plastic bottles.

1. It might be possible to use the community-involving methodologies CLTS and PHAST by transforming the focus from sanitation to waste management.

3. Create collective waste points for distant counties to arrange coordinated transportation to modern landfills.

    1. When villages and townships are solely responsible for waste management, it is expensive and uneconomic. Coordination on transportation, coupled with waste separation, will economize transportation while ensuring that less MSW ends up in illegal open air landfills.

Finally, a comprehensive study on the behaviorism behind waste management in rural areas should be done, to find the why's and how's that are most effective in making rural waste management changes happen at village level. This study should also incorporate benefit analysis to find which benefits are most valued by average rural dweller.

6.2.1. Waste management project ideas

1. Facilitation of biowaste, agricultural and horticultural waste separation.

    1. Facilitation of biowaste separation in rural or peri-urban setting to decrease waste transportation costs and to make waste management more pleasant and cost-effective. Would include planning of alternative handling for separated biowaste, for example village-scale composting site.

    2. The outcome of this project would be a set of tools on how to successfully facilitate waste separation, the economics of it and what kind of incentives are needed to make it happen in real situation.

2. Designing a rural waste management guidebook in cooperation with government officials, village leadership and private parties dealing with waste management.

    1. This would be a challenging project, but also within the capabilities of

students helped with professional people from the governmental field. Many countries have waste management guidebooks, these could be adapted to suit Kunming Municipality situation.

3. Planning and deploying a “Waste awareness” - campaign using for example a van or pickup car. The car could go around Dianchi Lake Basin and organize awareness campaigns in village groups.

    1. This project would be comparatively easy to arrange and manage and might yield some interesting results, if communities start to empower themselves and start to treat the waste problem as a community problem with community solutions.

    2. There is an American model that was targeted for small industries, A Guide to Creating a Mobile Waste Reduction and Recycling Demonstration Unit by Iowa Waste Reduction Center. This could be adopted to suit the Kunming situation.|15|

7. WASTEWATER MANAGEMENT

Wastewater is probably the worst environmental problem in Kunming Municipality, at least the one getting most attention due to the deterioration of Dianchi Lake. The government has responded to the situation by constructing wastewater treatment plants and wastewater infiltrators, by banning phosphorus-containing washing powders and implementing a large-scale dry toilet project to reduce the blackwater-based nutrients entering Dianchi Lake. Old lakeside has also been converted to wetlands to function as a buffer for non-point source pollution and to convert the nutrients into vegetation. There has also been at least one pilot project on harvesting fast-growing water plants as a possible solution for nutrient removal. |3||4|

Non-point source wastewater has proven to be the biggest problem to tackle. Coupled with seasonal rain during June-September of almost 85 % of annual rainfall, it is a difficult issue that has impact on public health and environment. There were no management systems in the field visit locations at all, except for UDDTs. The dry toilet

construction project was aimed exactly at reducing non-point source blackwaters input to Lake Dianchi, but has so far yielded little result and none that has been carefully verified. Handling the problem is expensive and without dedicated approach, little result is gained. This was the reason that the ways how wastewater is formed, how it is led away from the households and how it is led into either treatment or runoff were selected to be of interest.|4|

7.1. Rural wastewater transportation

There are four streams of wastewater in the rural and peri-urban areas of Kunming Municipality; industrial wastewater, municipal greywater, irrigation water runoff and blackwater. Of these the industrial wastewater stream is already covered by the impact assessments that regulated industries must submit to EPB. To get operation permit they must have suitable treatment for their wastewater fragment. Diluted greywater and blackwater is often used for irrigation by pumping or leading it from waterways due to agricultural and horticultural plots being around the village areas. Probably this is sometimes accidental, sometimes intentional.

Four ways to manage and channel rain- and wastewater inside villages and small towns were identified. Here is a description of each one:

1. Sewers, either small-bore pipe sewers or larger sewer systems
    1. Sewer systems are only built in the largest towns of Kunming Municipality: in Chenggong and Jinning. Some villages in Guandu have pipe sewers, but the water is usually led into canals or large ditches. The field visit locations did not have village-scale treatment systems. In some locations though the village leaders might have meant option 2 instead of real pipe sewers.
    2. The problem with sewers is that they require certain planning to be effective and reachable. Fast pace of construction with little supervision and management can mean that individual households do not connect to the sewer system, undermining it's efficiency. Rainwater is also problematic issue, because it can enter the sewer system and cause blockages and

flooding.

2. Covered, lined ditches
    1. These are most common in Kunming City suburban areas, as well as in those villages that can afford them. The ditches are lined with bricks and mortar or concrete and covered with concrete slabs. This is seems to be cost-effective method for relatively good wastewater transportation, but is still too expensive for most villages to do on their own.
    2. Covered lined ditches are partially open for rainwater, which means that they can flood during heavy rains. They are also breeding places for mosquitoes if poorly planned and water get to stagnant in ditches with no slope.
3. Open lined ditches
    1. These ditches are also lined with bricks and mortar or concrete, but lack cover. They are a cheap way to manage flow of wastewater.
    2. Open lined ditches are very susceptible for rainwater, but at the same time they also work in transporting the rainwater out of village premises, which is important in itself. However, field visits during rainy days showed that usually the ditches are inadequately dimensioned, leading to flooding of grey- and blackwater on streets and alleys.
4. Open ditches
    1. The cheapest and in most poor villages the only wastewater transportation method is open, non-lined ditches. They actually exist in almost every village in the outskirts, because most often the lined ditches only cover main streets.
    2. These ditches can crumble in heavy rainfall, are smelly and allow wastewater to percolate to groundwater.

Depending on location, the development status of the locality and the wealth of the household, the household wastewater can be led out of the house or yard by pipes into a nearby ditch, or simply led to the ground from a small hole in the wall. Finally the

wastewater ends up in a larger ditch or canal leading to a river or straight to the Dianchi lake or other water bodies, which include water collection dams and smaller lakes of the Kunming Municipality.

7.2. Wastewater control and treatment methods

According to Medilanski et al. (2006), there is a lot of enthusiasm for control at source as a solution for urban wastewater problem in the professional field of Kunming Municipality and China. Control at source would be ideal for rural and peri-urban settings also, but the control solutions should be low-cost, compact and light on maintenance to ensure function. The dry toilet construction project aimed at this, but sadly failed, so enthusiasm for alternative sanitation methods is now very low in the KMEPB. No village-scale methods were present at field locations.

7.2.1. Semi-urban control and treatment methods

There are three notable de-centralised wastewater treatment systems under testing in Kunming City, all of them relying mostly on biological filtration. These are wastewater infiltrators, curbside wastewater treatment and apartment building wastewater treatment.

Wastewater infiltrators, situated on riverbanks, work downstream from population centers, pumping highly polluted river and canal water into large biofilter systems, which is released further downstream after treatment. The biofilter utilizes activated carbon and varying species of water plants with more traditional sand and crushed rock. While the systems are currently doing little more than diluting the highly polluted water, they could conceivably have notable effect downstream of the population centers, if the treatment capacity is increased. These systems is only react to existing water pollution and do not prevent damage that has already happened to the river systems. The particular system that was observed was also infested with mosquito larvae, but this problem might abate in near future, if frogs or other larvae-eating

amphibians or insects populate the filter vegetation.

The curbside wastewater treatment systems are quite similar, except that they utilize the green curbsides. The system that was observed in Guandu District outside Kunming City collects household effluent from several apartment buildings and treats it in a biofilter before releasing it into the adjacent river.

The apartment building treatment system is similar to the curbside filters, but scaled for the apartment buildings alone: they treat greywater in small flowerbeds by the building. Blackwater is collected into effluent tank.

As of the writing of this report, no reliable, tested information was available on the actual treatment results of the different types of systems, so none is provided. Kunming Institute of Environmental Science can provide additional information on these systems.

7.2.2. Rural control and treatment methods

Single household-scale solutions are not ideal due to lack of space in most villages. Wastewater control should aim to service either household groups or whole villages, or even larger areas where possible. The treatment solutions should be affordable, use little space and possibly be labour-intensive. Labour is cost-effective in China, especially rural areas, and provides local income. One example of rural is the Shaxi Rehabilitation Project, where household-scale pretreatment is combined with village-scale post-treatment. More information of Shaxi Rehabilitation Project: http://www.nsl.ethz.ch/irl/shaxi/frameset/frameEcological.htm

> Simplified sewage with post-treatment in an integrated wetland system: The second technical component is a three-step process, including:
>
> 1. Pre-treatment of household wastewater in anaerobic baffled reactors (ABR) or other suitable systems
>
> 2. Transportation via simplified sewage
>
> 3. Post-treatment in integrated wetland systems, facilitating optional reuse of treated wastewater for agricultural and aquacultural purposes.
>
> *Text 2: Shaxi Rehabilitation Project: Ecological Sanitation Final Stage Funding Proposal*

The project is on-going, with the wetland system waiting for funding. However, if it proves to be cost-effective and works in the rural environment where maintenance is not quaranteed, it should be used as an example on rural wastewater treatment.

Sandec publication *Greywater Management in Low and Middle-Income Countries* has several treatment systems that have the potential to be suitable in the rural areas of Kunming Municipality, but are quite demanding on land area, require maintenance or are not exactly suitable for dense rural village. There are probably many examples in China of successful rural wastewater management, but for this report, applicable to Kunming environment and climate, none was found. |16|

As the situation in many villages is such that household effluent is more or less used in conjunction with irrigation water in agriculture without any treatment, one could argue that building a treatment system under the agricultural area that is the immediate receiver of the effluent would yield benefits. This calls to discussion the benefits of providing partial treatment or pretreatment versus no treatment at all.|4|

7.3. Future Projects

- Interesting concept that came up during the project is a small filter box design that could be installed under the household wastewater drains. It could collect the larger particles in household effluent and would provide a degree of pretreatment in villages that have no functional wastewater transportation. The problems with such design are many, starting with size restrictions, smell

problems and affordability, but due to the rural household wastewater production being quite low, it could offer “first aid” for villages suffering from household effluent problems.

- Study on how different water transportation methods affect village premises. This study would compare village premises in dry season and rainy season and analyze the effect of different ditches on the villages.
    - Results could be used to calculate the cost-effectiveness of different ditches compared to for example improvement in quality of living or incidence of diarrhea.
- Testing some of the treatment systems showcased in Sandec publication *Greywater Management in Low and Middle-Income Countries*. Some of the systems are rather affordable and could be modified to suit Kunming Municipality climate and other requirements.

8. CONCLUSIONS

Kunming Municipal Government has taken steps to protect rural environment, but there is still more to do. The central government of PRC China is adopting an approach called “circular economy”, aimed at reducing waste and energy usage and increasing recycling of materials and energy efficiency. Kunming Municipality is also required to move towards these targets, but they cannot be reached by concentrating on the well-being of urban areas only. |C 1|

There is a need to develop guidelines for the rural sanitation management and where these exist, offer tools for the actual management. However, where infrastructure is not sufficient to allow conventional management, innovative approaches must be taken. In case of waste management and lack of proper landfills in Kunming Municipality, community-involving approach to biowaste separation should be studied once more, to

find the proper approaches that motivate local people to spend extra time for better communities.

Community involvement should be taken seriously in Kunming Municipality, especially in Dianchi Lake Basin where rapid urbanization reforms traditional communities, waste generation and water consumption will grow but infrastructure cannot match the speed of urbanization. The traditional separation of private and public space must be broken, the private space must merge with public space to allow people to take responsibility on their local community and voice their concerns on sanitation issues. This will allow communities to act together in improving their local environment. There are tools for this already, CLTS and PHAST for example, that could potentially be changed from their original context into the one required by the issues at hand. CLTS has been used in China since 2005, so there exist knowledge in how to apply it in Chinese context. |18||19|

All these aspects also serve the KIES interest in the ecological village concept. Western European “Eco Village” is largely based on the individuals' need on improved, more environmentally friendly living and environment - this is achieved through personal input on bettering the community. Existing ecological village projects in China seem to be based on improved and green technologies and service, through external input, rather than resident output. By combining community involvement with the prominent green technologies, traditional knowledge and the mobilizative capacity of the government available in China, a new functional mixed approach is achieved, which will work not for the people, but with the people. |20| |7|

8.1. Recommendations on student participation in the umbrella project

I recommend that:

1. If the collaboration between TAMK University of Applied Sciences and Kunming Institute of Environmental Science continues, the students should be given choice in conducting projects dealing with community involvement,

coordination and management methodology testing and awareness raising. Alternative fields can be graphical information systems (Geographic distribution of waste/wastewater problems or unhygienic toilets for example) and field sampling analyses. These are in my opinion the areas that Environmental Engineering students of TAMK University of Applied Sciences are most suitable for, although I agree that preference should be put on what is required by Kunming Institute of Environmental Science.

2. Effort is made to ensure that both parties agree to what are the goals the students should achieve. These goals should be decided on before the students are sent to Kunming and if possible, not changed while the project is on-going. The goals should be such that they benefit KIES, but also serve TAMK.
3. Finally, I suggest that the Kunming University of Science and Technology students will be involved in the future – it could form a lasting partnership with the university and KIES could possibly involve the students in the project even when there are no TAMK students in Kunming.

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APPENDIX 1 – INTRODUCTION TO KUNMING MUNICIPALITY

Table of Contents

1. INTRODUCTION TO KUNMING MUNICIPALITY

Kunming Municipality is located in Yunnan province, southwest China. Yunnan is a border province, sharing borders with eight countries. The Kunming Municipality, with jurisdictional total area of 21,111 km^2, is geographically situated at the middle of the Yunnan-Guizhou Plateau and is inside of the Yangtze River, Nanpan River, and Red River's watershed regions. Kunming Municipality joins Southeast Asia on the South Asia channel key position, and thus has important regional status. Kunming city is located north of the Dianchi lake basin, and has an excellent, central geographical position inside the province. Kunming city, as the capital city in Yunnan province, is one of key cities in southwest China. |2|

1.1. Topography and climate

Topography from north to south assumes a ladder shape of which steps gradually decline and are drawn out. The majority of region is between 1500 ~ 2800 meters above sea level and forms a mountainous, hilly landscape. The Sedan Chair peak in the north, Luquang town, Horse Hair mountain range, tops at 4247 meters, but the lowest point at the junction of Pudu River and Yangtze River in Luquang County, is only 746 meters. Kunming city central area is at about 1891 meters and three borders of he city are hilly, while the south border is on the Dianchi lake shore. Kunming city is located

at 24°23' north latitude, 103°23' east longitude. |2|

1.1.1. Climate

Kunming is situated at low latitude plateau. The landscape is complex. Terrain elevation difference is large, and thus climate has vertical and horizontal differences. According to national meteorological data statistics, Kunming Municipality yearly average temperature is 14.5 ℃, hottest month (July) average temperature is 19.7 ℃, coldest month (January) average temperature is 7.5 ℃, and yearly temperature difference is 12 ~ 13 ℃. Whole year precipitation is approximately 1031 mm, relative air humidity is 74%, whole year frost-free period yearly average is above 240 days.

Average yearly insolation is 2445.6 hours, sunshine rate is 56% - as a yearly average the Municipality enjoys more sunny days than cloudy days. Solar projection angle is large, the yearly average bolometric radiation quantity amounts to 64.9 Kcal/cm^2 the rainy season 62.78 Kcal/cm^2, and the dry season 67 Kcal/cm^2. Difference between the two seasons is not large.

1.1.2. Seasonal climate

The Kunming Municipality geographical position is in the north latitude subtropics, however within the boundaries of the majority area summer does not have the intense summer heat, the winter is not severely cold, so the region can be better defined as having the warm temperate climate characteristics.[2]

Spring

In the spring, the air current comes from the mainland belt. Weather is sunny and the monthly average temperature is mainly below 20 ℃. However the diurnal temperature difference is large. Precipitation and air humidity are low, the transpiration rate is big, the temperature rise is fast.

Summer

During summer months the air current comes from tropical sea, multi- nimbus clouds

2 http://www.nujiang.gov.cn/ynstyjcyhwz/4326551867019493376/20060922/67710.html translated from Chinese..

are dominant cloud type and the air humidity is high. The soil retains moisture and ground absorption of solar radiation is reduced. Therefore during the midsummer season, besides areas which are below 1,600 meters sea level and able to achieve 22℃ average temperature, average temperature is below 21℃. One can say that the summer months are quite benign in the Municipality. Rainfall is concentrated on summer months, especially the 6th, 7th and 8th months when the precipitation is above 60% of the yearly precipitation. There can be multiple heavy rains daily and also rainstorms, which makes this rainy season most likely to cause floods and other water-related disasters.

Autumn

During the autumn temperature decreases quickly, the weather is dry, most areas see average temperatures 2℃ lower than during spring. The precipitation reduces about 50% compared to summer months, but it is more than spring and winter precipitation. Generally in the beginning or the middle of October the rainy season is finished.

Winter

The winter months average to about 20 cloudless days and to about 230 hours sunshine per month. The entire season precipitation only accounts to 3% ~ 5% of yearly precipitation. Besides river valley areas 1,500 meters below sea level, the whole Municipality has more than two months of winter (5 day average temperature to lower than 10 ℃). During the coldest days the weather is cloudy and it is possible to have snow rains, and the ground can be frozen.

1.2. The population, ethnic groups and religion

1.2.1. Urban areas

Kunming Municipality year 2005 total registered household population was 5.08 million people, of which non-agricultural population was 2.1121 million people. 58,796 people were born during the year, the population natural rate of growth being 6.23 ‰. |4|

Ethnic group	Population	Ethnic group	Population
Yi	391337	Lisu	17289
Hui	146922	Zhuang	13835
Pai	71443	Dai	13101
Miao	45013	Hani	10649

Table 2: Major ethnic minority groups. Kunming Municipality Yearbook 2006.

Kunming Municipality has ethnic minority population of 740,000 people, which is 14.6 % of the total population. There are 8 ethnic groups with a population larger than 10 000. |3|

450,000 people are (registered) religious. Kunming Municipality has 594 places of religious activity. The City has 6 religions, while the rural areas have 8 religious groups.

Religion	Registered persons
Buddhism	150000
Islamism	140000
Christianity (Orthodox, Lutheran?)	100000
Catholism	5 000 ~
Taoism	1 500 ~

Table 3: Religious groups in Kunming Municipality. Kunming Municipality Yearbook 2006.

Urban economy

Kunming City inhabitant average wage is approximately 801.33 RMB / month. The tobacco industry, mechanical and electrical industries are the major industry branches, while biological medicine, high technology and other emerging industries continue to grow stronger. |3|

1.2.2. Kunming Municipality rural areas

Population

The population in Kunming Municipality rural areas is ~ 3526400. Village sizes can vary from ~100 to ~1000 persons. |3|

Economy

In 2005 the total production value was 11.63 billion RMB. The agricultural production value was 6.4 billion RMB. The stock animal breeding production value was 4.1 billion RMB. The forest production value was 374 million RMB and fishery production value was 346 million RMB. The area of rice cultivation is 246800 hectares and the production is 1134000 tonnes. The flower production is also one of the main economic sources. In 2005 the area of flower planting was 5867 hectares. The total production of flowers was 3.16 billion flowers and the production value was 1.027 billion RMB. Exports account for 89% of total production. |4|

Rural income

The average annual net income is 3258 RMB in rural area, compared to the urban area annual net income of some 9600 – 10 000 RMB. In a small questionnaire done in two villages on west and east side of Dianchi lake, which was very limited in scope, we got answers ranging from 3000 annually (Taishi) to more than 30 000 annually (Zhonghe). This amount is by household, not by per capita. In average the eastern bank of Dianchi lake is richer than the western bank. There are many rural areas that are extremely poor. These areas account for example mountainous, poor soil and ethnic minority areas. |3|

Livelihood types

Rural area population work mostly in the agricultural and horticultural fields, although animal raising, forestry, construction and some service-oriented livelihoods exist also.

1.3. Administration

The administrative division divides Kunming Municipality to 5 governance districts, 1 city and 8 towns. The governance areas are *Wu-hua District*, *Panlong District*, *Xishan District*, *Guandu District*, and the *Dongchuan District*. The other city besides Kunming city is the Anning city. The towns are *Chenggong town*, *Yiliang town*, *Jinning town*,

Fumin town, *Gaoming town*, the *Shilin Yi* ethnic Autonomous town, the *Luquan Yi* ethnic autonomous town, *Xundian Hui Yi* ethnic Autonomous town.

The Municipality has altogether 30 townships, 315 community resident committees and 1255 village commissions.|3|

1.4. Environment and pollution

1.4.1. Water sources

There are 7 water sources that supply Kunming city drinking water. Five are surface water sources (dam reservoirs). These are Songhua reservoir, Dahe (Da lake) reservoir, Bao Xianghe (Bao Xiang lake) reservoir, Zi Weicun reservoir and Dian Lake. Dianchi lake water is so severely polluted that its usage is avoided, but currently necessary. (Dianchi lake accounts to about 17.5 % of total drinking water). There are only two groundwater sources supplying Kunming city: Hai Yuansi and Bai Longtan. It is not advised to use groundwater for drinking or cooking:

"The data of 974 monitoring sites, ... During the dry season, 10.9% remained excellent and 31.03% remained very good and 58.03% remained poor, with wide distribution of pollution. All pollutants, namely nitrite nitrogen, nitrate nitrogen, iron, manganese, coliform group bacteria, all varieties of bacteria, commonly existed above acceptable levels. " |7|

United Nations have listed China as one of the water shortage areas in the world and Kunming as one of the cities with bad water shortage.[3]

1.4.2. Atmospheric pollution

Yearly average particulate concentration is 0.085 mg/m^3 in Kunming City. SO_2 yearly average concentration is 0.069 mg/m^3 and NO_2: yearly average concentration is 0.040 mg/m^3. According to YPEPB, the air quality in 2003 in Yunnan cities was generally good, while none being bad. Note however that car ownership has risen rapidly since

3 http://www.unchina.org/theme/html/environment.shtml

then. |7|

1.4.3. Soil pollution

In recent years the pressure on land resources has risen due to growth of urban areas, lakeside protection and reforestation. Lakeside protection claims lands from farmers who have built to lakeside, to establish natural wetlands. Finnish YLE reported that the SEPA of China claims that about 10 % of Chinese fields could be so polluted that they can't be used for agriculture anymore.[4] This is due to the change of original farming practices and crops into using composite fertilizers and growing for example flowers. The information was for whole of China and probably applies only partially on Yunnan. However, Dianchi lake basin is one of the largest flower producers in the world and fertilizer usage is high. Other factors affecting soil pollution are heavy industry and poor sanitation. Poor sanitation leads to pathogen contamination in village areas.

1.4.4. Municipal waste

16.1.2007 Finnish YLE[5] reported that CCICD issued a warning that China is in danger of drowning to municipal solid waste. Without any doubt solid waste management (SWM) is one of the big challenges China faces in the near future. Kunming City situation is not so bad, as there is a modern landfill near the city, but outside the immediate City area, the problem gets incrementally worse. Worst areas are the rural villages that often do not have any kind of waste management, or even time / willingness to collect MSW. Often, if waste is collected, it is dumbed in illegal landfill.

1.5. Introduction to Dianchi Lake

Dianchi lake is an ancient tectonic lake with an area of about 300 km^2 and volume of about 1.56 * 10^10 m^3. The lake has been divided artificially into two parts – Caohai of

4YLE, 2007, http://www.yle.fi/uutiset/haku.php?action=page&id=246143&search=lannoitus
5 YLE 2007, http://www.yle.fi/uutiset/haku.php?action=page&id=238809&search=kiina

7.5 km^2, which is the northern part near to Kunming city, and Waohai, which is the southern part.

The lake belongs to Jinsha river drainage area and water from the lake flow west via Tanglang river towards north, until eventually ending up in the east and reaching Pacific Ocean. The drainage basin is approximately 2920 km^2, including the lake, which takes around 10% of the basin area. Kunming city, in respect, takes about 1.32 % of the basin area. The basin is about 100 km x 30 km area, with the long side being on north-south axis.

Lake water is replenished by precipitation, as there is no significant groundwater transfer nor artificial canals bringing water to the lake. Available water resources are limited, and the water scarcity problem has escalated with growing water usage, as average and especially dry years can't supply surplus water through precipitation due to consumption.

Rapid population change (1.50 million in 1980, 2,2 million in 2000, 3.16 million in 2003, population density 23600/km^2) in the drainage basin especially due to the growth of Kunming city have led to increased stress on water resources. The lake is used for many purposes that include flood control, industrial and agricultural water supply, aquaculture (significantly less now) and tourism. Since 1990 the lake water has been used increasingly for drinking water, but high pollution levels are forcing a change to use other water sources.

1.6. Defining stakeholders in Kunming Municipality sanitation field

Defining stakeholders is a complex process. Most of these stakeholder analyses for Kunming City wastewater management are by Edi Medilanski et al. |1|

Most important stakeholder can be defined as the government of People's Republic of China. As per Medilanski et al. the government is three-pronged: the legislative power is with the Congress, the executive power is with the government and the Communist Party is the ideological guide for government. The government is six levels deep,

starting from the Central Government of PRC and ending up at the village committee, which holds little to no legistlative power and limited executive power.

The local population is represented by the individual, by household and by the village commissions.

Inside the Kunming Municipality government, there are many departments that have an interest, open or vested, in the rural areas. From environmental protection and preservation point of view, the Dianchi Lake Protection Bureau, Yunnan Environmental Protection Bureau, and Kunming Municipality Environmental Protection Bureau are the most important stakeholders, while from ecosanitation point of view KMEPB, Kunming Institute of Environmental Science and Yunnan Academy of Social Sciences are the most important, due to them having done the previous pilot projects and KMEPB being responsible for the current project. |1|

From societal improvement point of view, the municipal congress, Chinese Academy of Agricultural Engineering, Municipal Public Health Bureau, Municipal Civil Construction Bureau and Municipal Agriculture Bureau are the most important governmental stakeholders.

There exists several industries that are major stakeholders in the rural areas. Most prominent industry branch, in Dianchi lake environmental context, would be the phosphorus mining companies around Dianchi lake. Also both animal and mineral fertilizer companies, are stakeholders due to the agri- and horticultural economy. |1| |2| |3|

1.7. Selected environmental technologies

1.7.1. Solar energy

Yunnan Province uses solar energy extensively, but surprisingly not so much is spoken about it. Solar energy is plentiful here as written in 1.2. However, conventional solar

radiation to electricity – implementations are still too expensive in Chinese context. However, Kunming City roofs are full of solar water heaters that supply both private homes and apartment buildings with hot water. A small 100 or 200-liter tank and water circulation panel costs about 1000+ RMB (100 €). As many breakthroughs are being done in solar panel technologies, it might became viable in coming years, especially as the panel technology becomes less reliant on energy-intensive manufacturing technologies and environmentally harmful components.

Following solar power technology improvements in coming years and investigating alternative uses of solar energy can yield project ideas that could be implemented in rural areas through subsidization. This would provide alternative energy sources with relatively short payback times due to Yunnan insolation conditions.

Illustration 1: Solar heater atop a home outside Kunming City. Miikka Ristkari, 2007.

1.7.1. Biogas

Robert A. White has done a case study of Lijiang Municipality in Yunnan. It handles household-scale biogas plant (HSBP) development in Lijiang very thoroughly. I also suggest reading a promotional document *"The Promotion of Rural Domestic Biogas Plants in P. R. China"* by Hu Qichun[6] for numerical data on rural HSBPs, as well as older online document *"Anaerobic Digestion in Rural China"* by Paul Henderson concerning HSBP design and construction.[7]. According to Hu, there are are about 18 million HSBPs in rural areas of China and there might be a potential for up to 150

6http://www.hedon.info/docs/20060406_Biogas_promotion_China.pdf

7http://www.cityfarmer.org/biogasPaul.html

million units. The two major models used are:

- *"The hydraulic biogas plants (fixed dome) is still the main type of digester with National Standard Design Drawing GB/T4750-2002 as a representative type in China."*
- *"...biogas digesters with separated floating gas drum in Hunan province and more numbers of the digesters with strengthening slurry recycle."*

Illustration 2: Completed reactor showing dome top, gas port and toilet and pig pen influent channels at right. Entire structure will be covered with pig pen floor. Picture by Paul Henderson.

HSBPs in China are usually buried vaults, called either the 3-in-1 or 4-in-1 design. In south, as in Yunnan Province, 3-in-1 is the usual type. 3-in-1 means "three systems in one package" and includes the biogas digester, a pig pen and a latrine constructed in close proximity to facilitate easy usage. In Lijiang there are about 48 000 HSBPs with some 140 000 more to come by 2010. Average 3-in-1 model costs ~1800 RMB in total, so this is a huge investment by rural population.

In Lijiang, introduction of HSBPs started at 1980's, but wide scale adoption has only taken place since late 90's with the help of international NGOs, who provide subsidies and technical and managerial expertise. Lijiang Forest Bureau, World Wild Fund and The Nature Conservancy worked together on the project. The aim was to reduce forest resource usage for firewood and to reduce poverty, thus protecting the environment. |6|
In short, the implementation of the HSBPs was done by seeking ideal households to introduce heavily subsidized or free pilot reactors to create demand. A subsidization package was created to help rural population finance the reactors when demand increased. Technical extension service was formed with training of local population in

biogas digester technology and spare parts depots included.

This successful project in Yunnan implies that it could be adopted in Kunming Municipality. There are about 10 000 HSBPs in Kunming, according to Liu Shuzhi from KIES. There is also a Biogas Office at Rural Agriculture Agricultural Institute. (Nongcun Nongye Nongyuan). It might be worthwhile to investigate the present situation in Kunming and form a project around HSBPs by following Lijiang Municipality model and experiences to improve the rural economy, environment and sanitation situation.

1.7.3. Dual-chamber composting and bio-filter systems

Farmer-operated dual-chamber composting (DCC) system is a patent by Wang Hongtao et al. It is used extensively (according to KIES) in the rural areas around Dianchi lake. A good presentation by Wang Hongtao, titled *"Control of Non-point Source Pollution in Dianchi Lake Catchments"*[8], gives an overview of the bio-filters used in urban wastewater filtering and on dual-chamber composting.

Dual-chamber composting is in itself quite novel. The idea is to prevent percolation of composting liquids into the ground and ultimately to Dianchi lake and at the same time retain the nutrient-rich liquid for irrigational purposes. According to Wang, it also suits the traditional handling of agricultural leftovers as composting has quite long history in China. (Interestingly, this does not seem to apply for household biowaste even in rural areas, but only to agricultural leftovers. Author's own observation.) However, there are some downsides to DCC. First, the compostors are breeding pits for fly and mosquito larvae, as can be seen from picture 11. Secondly, again by the author's observation, farmers are not actually using the compostors as shown in picture. When we have done field visits, I often see compostors with rubbish in them, or which are otherwise empty and abandoned-looking. Agriculture is of course seasonal, so observations might have been done at wrong time.

8 http://www.alcoa.com/global/en/community/pdf/2006_conference/day1/s4_wang.pdf

Illustration 3: Dual-chamber composting system. Picture by Wang Hongtao.

Illustration 4: Fly larvae breeding in DCC liquid chamber. Picture by Miikka Ristkari, 2007.

Not much information is available in English of this type of composting. By account of KIES personnel, it is efficient compostor when used right. It might be interesting to do independent study of the DCC system to compare how it relates to traditional composting on ground, to see how it is actually used in Kunming Municipality and whether the design could be improved upon to for example cheaply remove the larvae breeding problem.

Illustration 5: Wastewater interceptor using biofiltration design under construction. Miikka Ristkari, 2007.

Bio-filter technologies in Kunming are based on layered filtration materials.The idea in itself is interesting, as if it can be “commercialized” into compact and cheap but fairly effective packages, it could address for example downhill wastewater runoff, or potentially even individual-scale households in the rural areas. At the moment though, what I have seen here in Kunming Municipality, biofiltering technologies have only

been implemented around Dianchi lake, which is of course the most important area in environmental sense.

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APPENDIX 2 – SURVEY TO ZHONGHE AND TAISHI VILLAGES

Report on survey to Zhonghe and Taishi villages

Document responsible organization:
Kunming Institute of Environmental Science
Tampere Polytechnic University of Applied Sciences

Date started: 2007-05-08
Date last modified: 2007-05-14

Draft started by Yang Chenxi
Final by Miikka Ristkari

Brief:

This document is a report on our open questionnaire survey to Zhonghe and Taishi villages. The surveys were conducted on 19th and 20th of April. We found out that the main reasons for abandoning or rejecting the urine-diverting dry toilets are bad quality and faulty design, as well as difficulty in use. However, the survey only covered 21 households.

Relevant documentation:
Survey Statistic_update.xls
Social_acceptance_of_dry_toilets_in_zhonghe_village_PAMS SEA-3 YASS FR.pdf

1. Background

After reading the “Social acceptance of dry toilets in Zhonghe village” by Liang Chuan et al., it was decided we decided to conduct a small survey to Zhonghe and some other village. This other village came out to be Taishi, as these villages represent the two ends of village life and living conditions, mainly rich and poor villages. The purpose of the survey would be to introduce the village life to us, as well as to give us firsthand information on the situation with the dry toilets.

Taishi village had a failed dry toilet introduction project in 2002-2003.
Zhonghe village had a partially successful dry toilet project in 2003-2005.

2. Forming the questionnaire

The questionnaire was formed by making a draft after examining a few sample surveys. After the draft we held discussion and analyzed the questions, and through discussion an open questionnaire paper was made. he survey paper involves general questions of family, sanitation and the household economy. The questions were chosen to be quite broad to get different kinds of opinions from the respondents.

3. Survey locations and selection method

We chose two villages, Zhonghe village and Taishi Village. Zhonghe was chosen first and we finally chose Taishi because it was the first village to receive ecological dry toilets. Before constructing ecological dry toilets in Zhonghe, the Kunming Institute of Environmental Science had done groundwork and educational campaings with the villagers. We want to see how is going on after 2 years.

Zhonghe and Taishi are both located by the Dianchi Lake. Zhonghe village belongs to Dayu Township and Chenggong county and has a population of around 400. The Taishi village belongs to Gucheng Township and Jinning County and has a population

of around 370.

4. Conducting the survey

Before going on with the survey, we decided on the methods on how to conduct the survey. The surveys would be open and the surveyors would avoid leading the respondents into answers, but rather we wanted the respondents to discuss the problems in their own initiative. We would ask the questions from the questionnaire and write down the answers, while sometimes giving comments and probing further into the issues.

4.1. Zhonghe village

On 19th of April we went to Zhonghe village. When we arrived to Zhonghe village we separated into two groups of 2 and 3 persons. This was to get a more coverage during the short time we had in the village. After about 4 hours we got 17 questionnaires back totally. Yang Chenxi was the surveyor in 2 person group and Ma Wenting in 3 person group. Other people present were Miikka Ristkari, Pu Limin and Yang Hongfu.

4.2. Taishi Village

20th of April we visited Taishi village. We spent there about 2 hours, during which we walked around the village and and spoke with the residents. In Taishi we surveyed only three households with the questionnaire, as the visit was more like an inspection and familiarization visit for us. We were three persons, Miikka Ristkari, Yang Chenxi and Pu Limin.

5. Results and discussion

After this open interview - survey, we found that only few families still use private ecological dry toilet. Mostly families would like to use public ecological dry toilet and also some families are still using old traditional toilet. In some occasions the households said they used ecological dry toilet, put the toilets were clearly not used. Also at least one household responded that they use the private ecological dry toilet during winter, as there is less smell then.

There are many reasons to cause the people to be unable or unwilling to use private ecological dry toilet. Technical reasons are wrong toilet location, bad toilet quality, difficulty to empty and difficulty to use. Social and habitual reasons are against living customs, against habits, against culture (as in Han-zu fengshui). Practical reasons are wrong location and ease of use of the traditional toilets, as well as fear of bad smell.

Problems associated with ecological UD dry toilet					
Bad smell	Uncomfortable	Wrong Location	Bad Quality	Faulty design	No problems
1	1	1	4	3	8

Table 4: Problems with ecological dry toilets

It is not wise to make any conclusions based on such a small survey population, but it seems that the public ecological dry toilets are quite well received. (This also based on field visits to several public ecological dry toilets elsewhere than these two villages.) With a maintenance and cleaning infrastructure and a bit improved design[9], they might provide a good way to access large population in the countryside.

This survey will help us in forming a bigger survey, which will hold educational (or, as a better word, informational) campaign elements aimed at gathering diverse opinions in Kunming municipality.

9 Defining improved design really belongs to elsewhere, but it could be: bigger emptying holes, door opening towards outside

6. Appendix

Appendix 1. Questionnaire

Kunming Municipality UD dry toilet survey

KIES TAMK

Surveyer:		Date:	
		ID:	
County			
Township			
Village			

Respondent family name:						
Respondent gender:		Female	Male			
Respondent age:	5-10	11-20	21-30	31-40	41-60	61-90
Respondents household size:		1	2	3	4	5-

Sanitation	
Types of toilets household members use while in home	
what kinds of toilet did you used most often	
Types of toilets household members use while in work	
What is the toilet preference, i.e. what kind of toilet is most liked?	
Why is this kind of toilet(s) liked the best?	
Problems and advantages of the toilets in use?	
How could the toilets be made better?	
What is a comfortable place for a toilet?	
Public or private toilet is better?	
Why is public or private toilet better?	

Kunming Municipality UD
dry toilet survey

Surveyer:	

Date:	

ID:

County:	
Township:	
Village:	

Economics

Household livelihoods	
Household income, annual?	
How much money is used annually on health issues? Whole household together.	
How much on stomach sickness, diarrhea?	
How much money would good health be worth?	
How much would the household use on toilet / sanitation?	
Would the household pay or want money if there was a person/company to empty the toilet?	
How much would the household pay or want money per year?	
The type of fertilizer	
The types of cropper	
The production of croppers	
The production value of croppers	

Ecological sanitation

What things could be done to make the village more comfortable place?	
What are the most important environmental things to be done in the village?	

Appendix 2. Detailed survey data

Respondents	
Zhonghe	Taishi
17	3

Illustration 6: Respondents in respective villages.

Gender		Age			
Male	Female	21−30	31−40	41−60	61−90
7	13	5	4	4	7

Illustration 7: Gender and age of respondents

Family size				
1	2	3	4	5−
1	5	7	0	7

Illustration 8: Household size.

Fertilizer used by household		
composite fertilizer	Animal manure	No answer
10	5	5

Illustration 9: Fertilizers used by households.

Household income			
100−2000	2000−5000	6000−10000	20000−
2	3	5	8

Illustration 10: Household income. Zhonghe is very wealthy village due to horticulture, this explains high incomes.

Annual health spending		
100−2000	3000−7000	8000−
5	5	1

Illustration 11: Money spent on health per household.

stomach sickness, diarrhea			
Often	Sometimes	No	No answer
2	6	5	7

Illustration 12: Stomach sickness incidence.

Toilet in household		
Old Dry Toilet	Eco-Dry Toilet	None
2	14	4

Illustration 13: Household toilet.

Toilet used during working time			
Traditional toilet	Eco-Dry Toilet	Outside	No answer
6	2	4	8

Illustration 14: Toilet used during working time.

Respondents' favourite toilet			
Eco-Dry Toilet	Traditional Toilet	Public Eco-Dry Toilet	Public Traditional Toilet
12	1	4	2

Illustration 15: Respondent's favourite toilet - does not reflect household view.

Most often used toilet			
Traditional toilet	Eco-Dry Toilet	Public Eco-Dry Toilet	No answer
4	9	4	3

Illustration 16: Most often used toilet.

Appendix 3. Numerical data of some answers of the survey

Village	Zhonghe				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
	Taishi	1	1	1																		3
Annual household income	100–2000	1																			1	2
	2000–5000			1							1										1		3
	6000–10000				1	1				1					1				1				5
	20000–						1	1	1			1	1	1		1		1		1			9
Annual household health spen	100–2000				1		1		1		1											1	5
	3000–7000	1				1		1				1							1		1		6
	8000–																	1					1
Types of Fertilizer	Composite	1			1	1		1	1	1		1						1	1	1	1		11
	Manure					1	1	1				1									1	1	6
Toilet used most often	ODT				1	1			1		1												4
	EDT		1	1			1	1		1				1	1		1				1		9
	PEDT	1										1				1		1				1	5
Toilet used in work	ODT				1	1	1	1	1				1										6
	PEDT											1							1		1		3
	Outside	1	1	1						1													4

Illustration 17: Selected tables for easy reading and cross-referencing.