Wastewater Management in Kunming, China: Feasibility and Perspectives of Measures at the Source from a Stakeholder Point of View

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1. Abstract

Large sewer systems with central wastewater treatment plants were long considered a success model that could be exported to practically any city of the world. This centralized highly water consuming system has however shown its limits in some developing and transition countries, especially in fast growing cities with limited water resources.

Based on individual interviews of the main stakeholders with an interest in the wastewater situation around Dianchi Lake (Yunnan, China), we investigated the feasibility and perspectives to introduce measures at the source (MAS) for the different urban wastewater contributions in the city of Kunming. In addition, the potential of two different sanitation alternatives allowing the separation and reuse of human excreta as fertilizer were evaluated by the stakeholders. Those alternatives were (a) the urine diverting dry toilet, a waterless two-chamber system often used in ecological sanitation and (b) the NoMix toilet, a urine separating flushing toilet developed in Europe.

We found that most of the stakeholders interviewed generally approve of measures at the source, especially for industrial wastewater and toilet waste. Although today's technical solutions are generally considered to be still inadequate, there is a prevailing optimism with respect to technical developments and increased environmental awareness within a relatively short time span of 20 years. Based on these findings, we consider it well possible that China will prove one of the most interesting and productive 'laboratories' for the development of decentralized wastewater treatment alternatives.

2. Introduction

The water and sanitation question is one of the oldest and most fundamental ecological challenges of urbanization. Both human health and environmental quality are at stake and large amounts of valuable resources like water and nutrients are involved.

Historically, Europe has relied on sewer systems to assure urban hygiene with centralized wastewater treatment plants optimized for water pollution control. For a long time it was generally accepted that this success model could be exported to any area of the world, at least in an urban context, given that sufficient means were invested. The flushing toilet became a

symbol of comfort and cleanliness and in many cases the complexity of a sewer system with centralized wastewater treatment were neglected.

It is now generally recognized that under certain circumstances, this strategy leads to failures. In cities with rapid urbanization, lack of water resources compared to the population density and a chronic shortage of capital, a centralized sewage system may not be the best choice. When cities are growing fast, it takes considerable discipline, thorough planning and much experience to expand concomitantly the invisible system of capital-intensive sewers and at the same time make sure that sufficient treatment capacity is available. The available financial resources are typically fully used for the construction of the sewer lines, which are normally responsible for about 80% of the total investments in centralized wastewater systems. For instance in Latin America, where a relatively large proportion of the population is connected to a sewer system, it is estimated that only about 10% of the collected sewage is treated at all and the quality of treatment is generally low.⁽¹⁾ With rising population density as compared to the water resources available for wastewater dilution, the task of water pollution control also becomes increasingly difficult, eventually leading to situations that can hardly be managed with existing end-of-pipe technology.⁽²⁾

Also in Europe, it is well recognized that end-of-pipe technology is not suitable to solve all problems connected with wastewater treatment. During the last decades, measures at the source therefore became an integral part of European mainstream wastewater management. Such measures have been especially successful in the case of non-degradable detergents that were prohibited during the 60'ties⁽³⁾, the control of heavy metal emissions in industry⁽⁴⁾ and in some countries a phosphate ban for detergents⁽⁵⁾. Wastewater in a municipal sewer system is a mixture of domestic wastewater, industrial wastewater, non-polluted storm water and infiltration water from rivers and small streams. In Europe, technical measures at the source are mainly taken for industrial wastewater and for non-polluted wastewater. Industrial wastewater is targeted due to toxicity and high contents of non-degradable organic compounds. The measures are based on on-site treatment and source separation, often leading to internal savings of water and other resources.⁽⁶⁾ Dilution with non-polluted wastewater impairs the wastewater treatment process and leads to higher loads of untreated wastewater being discharged during rain. The main actions taken to solve this problem are maintenance of the sewer system to prevent infiltration of groundwater, infiltration of rain water into the ground or separate sewers.^(7, 8) Domestic wastewater is normally divided into black water (toilet wastewater) and grey water (the rest). In Europe, measures at the source for domestic wastewater are based purely on regulation, like the ban of non-degradable detergents and

phosphates in washing powder or regulation against the discharge of toxic materials such as paint at the household level.

It is of course possible to extend the measures at the source for domestic wastewater beyond pure regulation. The notion of waste design discussed in^(9, 10, 11) examines the possibility of achieving favourable changes in the composition of domestic wastewater based on source separation. If concentrated waste streams are separated at the source and intermediately stored or treated separately, the centralized wastewater treatment process can be optimized. The best known example of waste design is urine source separation that has been extensively examined in literature over the last years.^(e.g. 12, 13, 14)

In rapidly growing cities, measures at the source would be even more attractive than in the mature cities in Europe. This is especially the case if a combination of such measures can replace the centralized system in entire parts of these expanding cities, avoiding the necessity of building capital-intensive sewers. In the present paper, we look into the situation of South East Asia, exemplified by the city of Kunming, the capital of the Chinese province Yunnan located north of Dianchi Lake (Figure 1).

Figure 1. The city of Kunming lies on the northern shore of Dianchi Lake, a nationally important lake, listed in the ‘Three Important Lake Restoration Act in China’ (map drawn after 17)

In the 1950ies, Dianchi Lake had reportedly clear water and people swam in it, but since then industrialization and an increased urban population have turned the lake into one of the most

polluted lakes in China.⁽¹⁵⁾ Furthermore, the ‘Greater Kunming Metropolitan Area’ is a rapidly expanding city, with a planned increase from today’s 2.6 million people to 4.5 millions in 2020.⁽¹⁶⁾ The lake is heavily eutrophised with phosphorus as the limiting growth element for algae, the main origin of phosphorus discharges into the lake being the wastewater of the city of Kunming.⁽¹⁷⁾ Six modern biological wastewater treatment plants were built between 1988 and 2001 with a treatment capacity of 580’000 m³ of wastewater per day.⁽¹⁸⁾ In a material flow analysis, however, it was shown that only about 25 % of the wastewater actually reach the treatment plant. Furthermore, due to the high population density and other phosphate producing activities (e.g. agriculture), even with the best available end-of-pipe technology the carrying capacity of the lake would still be exceeded at the current population level.⁽²⁾

The 5 Year Plan issued in 2001 foresees additional measures at the source, most prominently a phosphate ban for detergents and the introduction of urine source separating dry toilets in rural and peri-urban areas.⁽¹⁹⁾ Since urine, faeces and detergents are the main sources of phosphorus in domestic wastewater, both measures are well suited to reduce the phosphorus load to the lake. However, measures in rural and peri-urban areas alone will not solve the complex problem of Dianchi Lake that is very heavily overloaded with phosphorus (for a detailed mass flux analysis, see ²).

Urine source separation is found in two fundamentally different designs: the urine diverting dry toilet (Figure 2a) and the urine separating flushing toilet (NoMix toilet, Figure 2b). These two toilet designs are intended for different situations. The NoMix toilet was developed in Sweden in the early 1990ties as an alternative to the conventional flushing toilet and closely mimics this toilet, whereas the urine diverting dry toilet is a hygienically improved and odourless latrine toilet. From a technical point of view, the main difference consists in the NoMix toilet being a flushing toilet that still depends on water for flushing of faeces, whereas the dry urine-diverting toilet functions totally without water and any further water-borne transport and processing of faeces. This latter toilet allows for an efficient desiccation of faecal material for safer reuse as fertilizer, an important aspect in ecological sanitation. The NoMix toilet is very flexible and can be used for optimizing existing centralized wastewater treatment with or without the option of nutrient recycling.⁽²⁰⁾

First results indicate that the NoMix toilet is relatively well accepted in Europe although there is still scope for improvements with respect to design and technology.^(21, 22) Equally, the NoMix toilets have been well received in a number of pilot projects in institutional settings.^{(23,}

²⁴⁾ The little evidence obtained with the dry urine diverting toilet in personal households⁽²⁵⁾ emphasizes how important it is that the toilets are used correctly and that the users are properly involved in all aspects of the implementation process.

In the present work we aim to understand how stakeholders evaluate the potential of different measures at the source to solve the wastewater problems of Kunming and the possibility of such measures being introduced in the future. On the one hand we want to understand, how Chinese experts generally judge the importance of measures at the source for the single wastewater sources. On the other hand we investigate the special attitude of these same experts towards the concept of urine source separation in an urban context, an old Chinese tradition and a measure already foreseen for rural and peri-urban areas in the catchment area of Dianchi Lake.

Figure 2. Two urine separating sanitation alternatives: a) the urine separating dry toilet functions without water (drawing is courtesy of Lin Jiang, Guangxi Province, China), b) the urine separating flushing toilet (NoMix toilet; from Roediger, Germany)

3. Methodology and proceeding

We relied on expert interviews to identify the attitude of the most important stakeholders towards different measures at the source (MAS) for more effective wastewater treatment. Meuser and Nagel⁽²⁶⁾ define an expert as a person with a specific responsibility for the draft, implementation and control of a problem solution, as well as a privileged access to information. According to this methodology, experts represent the problem solving capacity and decision structure of an organisation or an institution. We selected a number of stakeholders who would act as experts for the introduction of urine source separation in

Kunming and conducted interviews with representatives of those stakeholders. The stakeholder interviews are generally highly structured with a large number of closed questions, but with important extensions based on the model of problem-centred expert interviews. Witzel⁽²⁷⁾ describes this type of interview procedure as very loosely bound to a well defined topic, giving the interviewee the opportunity to freely add qualitative information.

In a previous work⁽²⁸⁾, we identified and characterized the stakeholders that may potentially play a role in the implementation of urine source separation in the city of Kunming (Table 1). We met representatives of most of these stakeholders for a one-hour interview using a structured standardized guideline that allowed us to collect both qualitative and quantitative data. Technical fact sheets were prepared as a support to convey information to the stakeholder representative during the interview. Figure 3 illustrates the interview guideline followed and the interventions with the fact sheets at different stages of the interview to present the concept of measures at the source (MAS), the central role of urban sanitation for the pollution of Dianchi Lake and the two urine source separating alternatives. The interviews usually took place in Chinese and the answers with qualitative information were taken down. The quantitative answers were directly written by the interviewee in a previously prepared form.

Figure 3. The guideline to conduct expert interviews is constituted in three parts. The third part was used for a stakeholder analysis published in a previous work and will not be further discussed in this paper

The interview was structured in three parts:

In part 1 of the interview, the concept of applying measures at the source (MAS) for improving wastewater management was introduced and discussed. MAS for five different wastewater sources (Figure 4) were evaluated.

Figure 4. The end-of-pipe concept for wastewater management. The different wastewater sources (black water, grey water, industrial wastewater, rain and river water) are mixed in a sewer system and centrally treated by a wastewater treatment plant (WWTP; modified from 29)

In part 2, the two urine separating alternatives illustrated in Figure 2 were presented and the potential and limitations for urban implementation were evaluated. Different aspects as well as the future perspectives for these alternatives were taken into account.

In part 3, the stakeholder representative described the activity of his or her organization and the relationship with other stakeholders. This part of the interview helped us refine the stakeholder analysis presented in⁽²⁸⁾ and is not further discussed here.

In order to compare the qualitative statements of the interviewees, we treated the data based on the methodology described in⁽²⁶⁾. The qualitative answers were first written down as they were expressed by the interviewee. The resulting text was then paraphrased without modifying the information content to facilitate the comparison between the interviews. The answers were then summarized with keywords or short sentences to concentrate and better visualize the information. Finally the answers were thematically compared between the interviews and grouped according to the criteria whether the stakeholder saw a potential or a limitation for the specific aspect in question. The stakeholder representatives making similar statements were counted.

The interview guideline and the fact sheets were initially pre-tested with five stakeholder representatives in China to improve the procedure before conducting the final interviews according to the guideline presented in Figure 3. The test-interviews were discarded and new interviews were conducted with other representatives from those five stakeholders.

4. Results

4.1 *The stakeholders*

35 stakeholders were identified (Table 1), mainly governmental offices under the Kunming jurisdiction, five non governmental stakeholders (#7, #30, #31, #32, #33) and five stakeholders outside of Kunming (#13, #14, #15, #34, #35). About a quarter of the stakeholders are research institutions. See⁽²⁸⁾ for an overview of the Chinese political and administrative structure relevant for wastewater management and the status of the stakeholders with respect to interest and decision making power in relation to urine source separation.

We conducted interviews with representatives of most of the listed stakeholders. Only the Municipal Government (#1), the Municipal Public Utilities Bureau (#5) and the Municipal Law Bureau (#16) could not be reached for an interview. Double interviews were made with two stakeholders (real estate, #7; Qinghua University, #13), resulting in a total of 34 interviews.

4.2 *Part 1: Evaluation of the concept of measures at the source (MAS) for the city of Kunming*

1.1 General evaluation of the implementation of the concept in the city

The quantitative estimates of present and future implementation of MAS in Kunming are summarized in Figure 5. The current implementation of measures at the source in the city of Kunming is considered very low with 85% of the stakeholder representatives considering that they are “not at all”, “very little” or “little” implemented now. In 20 years from now, this situation is believed to be reversed with 85% foreseeing those measures “much” or “very much” implemented.

Table 1. List of the identified stakeholders who could play a role in the implementation of urine source separation in the city of Kunming

#	Stakeholder
1	Municipal Government
2	Municipal Communist Party
3	Municipal Congress
4	Dianchi Lake Protection Bureau
5	Municipal Public Utilities Bureau
6	Municipal Foreign Affairs Bureau
7	Real Estate (two interviews)
8	Kunming Sewer Corporation
9	Yunnan Environmental Protection Bureau
10	Provincial Institute of Environmental Science
11	Municipal Environmental Protection Bureau
12	Kunming Institute of Environmental Science
13	Qinghua University, Beijing (two interviews)
14	Research Center for Eco-Environmental Science
15	Chinese Academy of Agricultural Engineering
16	Municipal Law Bureau
17	Kunming Water Supply Company
18	Yunnan Academy of Social Science
19	Provincial and Fertilizer Station
20	Environmental Monitoring Station of the Yunnan EPB
21	Municipal Public Health Bureau
22	Municipal Civil Construction Bureau
23	Municipal Agriculture Bureau
24	Municipal Urban Planning Administration Bureau
25	Municipal Financial Bureau
26	Dayu Township Government
27	Chenggong Environmental Protection Bureau
28	Taishi Township Government
29	County Fertilizer Station
30	Zhonghe Village (rich village)
31	Taishi Village (poor village)
32	Phosphorus Mining Company
33	Kunming University of Science and Technology
34	Tianjin Environmental Protection Bureau
35	IRL-ETHZ Sib Denx Village Rehabilitation Project

Figure 5. Evaluation of the general concept of measures at the source (MAS) in urban wastewater management

The open interviews established that about two thirds of the stakeholders support measures at the source in a general way, and that only one stakeholder – the Municipal Urban Planning Administration Bureau – does actively not support this concept. Eight experts see the most important potential for measures at the source in new urban areas without existing water infrastructure. A number of barriers are seen at the political, financial and technological level and with respect to public awareness. Interestingly, the most frequently mentioned barriers are political (mentioned 9 times), whereas technical barriers were the least frequently mentioned (only 6 times).

1.2 Detailed evaluation on five wastewater sources (priority and feasibility)

The five wastewater sources evaluated were black water (toilet wastewater), industrial wastewater, grey water (domestic wastewater without black water), rain water and river water. The quantitative information is summarized in Figure 6.

Black water and industrial wastewater are both perceived as the wastewater sources where MAS are most urgent with over 90% of the stakeholders ranking this priority as “high” or “very high”. Specific measures for rain water were given a “high” or “very high” priority by half of the stakeholders whereas less than 30% find that MAS for grey water and river water have the same level of priority.

Despite the high priority given to the implementation of MAS for toilet wastewater, the feasibility of such measures is at the moment considered very low with only 30% of the stakeholders considering the present feasibility “high” or “very high”. Perspectives after twenty years are however more promising with this feasibility improving to 85% for excreta and between 74 to 97% for the other wastewater sources.

Figure 6. Evaluation by the stakeholders of the priority and feasibility to implement measures at the source on the different contributors to the wastewater

The qualitative statements for the implementation of measures at the source on the different contributors of the municipal wastewater are summarized below:

There is a broad awareness of the fact that industry increasingly treats its own wastewater with 20 experts mentioning this fact. Also grey water recycling is relatively well known with 10 experts making such a statement. For black water, 7 experts are in favour of decentralized wastewater treatment, but technical difficulties and a lack of public acceptance were mentioned. Strikingly, the measures at the source to keep the unpolluted storm water and river water separate from the wastewater are met with some scepticism by Chinese stakeholders. Although between a third and half of the experts are aware that these measures are actually

taken in Kunming, especially the importance of MAS for rain water is not recognized: 20 of the experts are doubtful as to the usefulness of such measures which are highly favoured in Europe. Similar doubts were expressed with respect to grey water, where 13 experts find MAS to be not useful.

1.3, 1.4 Comments on the concept of separate collection and reuse of human excreta

Following a presentation on the key contribution of flushing toilets to the poor state of Dianchi Lake, a specific discussion on excreta was conducted. Nearly half of the experts see a great potential for recycling urban nutrients, but the argument of household preference for the hygienic advantages of flushing toilets was repeated (explicitly mentioned by 9 experts).

4.3 Part 2: Evaluation of the urine separating alternatives

The urine separating dry and flushing toilets were presented to the stakeholders who commented on them in general terms before discussing specifically their different aspects.

2.1 General evaluation of the sanitation alternatives

The European NoMix toilets with a price of about 1000 US\$ are of course considered exorbitantly expensive by most of the experts (22 experts). Based on Chinese experience, we assumed a price of about 25-60 US\$ for a dry urine separating toilet, a price much more acceptable to the experts. Lack of acceptance was mentioned by 10 experts as a problem for NoMix toilets and by 14 experts as a problem for the urine diverting dry toilet. Whereas the technology of the NoMix toilet is considered a problem by 7 experts, there were more detailed comments on the technical problems of the urine separating dry toilet, a technology much more familiar to the stakeholders interviewed. Eleven experts commented on the unsuitability of this toilet in an urban context. Especially the problems of providing ash, lack of space and acceptable management were mentioned. However, 4 interviewees from the research field who support the concept of waterless urban sanitation proposed adaptations for more acceptable dry toilets in urban areas: large collective containers could allow smaller chambers in the individual households and a public collection service for the excreta would minimize the labour required by the family.

2.2 Specific evaluation of the sanitation alternatives on five different aspects

Figure 7 shows the quantitative evaluation of the two urine source separating alternatives with respect to technical, institutional, financial, environmental and social aspects. With the more focused questions, the different perception of the two toilets is covered in more detail.

The technical aspects of both urine source separating alternative were evaluated very positively with somehow a better feasibility for the NoMix (82% evaluating this alternative as positive or very positive) than for the dry toilet system (70%). Institutional aspects and the social acceptance in cities are perceived as clearly better for NoMix (79% and 53% of positive votes respectively) than for dry toilets (38% and 24% respectively) and both alternatives scored very well on the environmental aspects (82% for NoMix and 97% for dry toilets). Only the financial aspects are considered strongly negative for NoMix toilets with 12% of positive votes against 79% for the dry toilet alternative.

Figure 7. Quantitative evaluation of the two different urine separating toilets on five different aspects. The ranking spans from very negative (--) to very positive (++)

The most remarkable results from the qualitative statements are the remarks on technical feasibility, which for both alternatives are seen as unproblematic by about 18 experts, and the obvious fact that the NoMix toilets are far too expensive for the Chinese population (22 experts). There are large minorities expressing that the management of NoMix toilets would be easy (11 experts), that dry toilets are inconvenient in an urban setting (6 experts) and that the environmental impact of the dry toilets is better than for the NoMix toilet (8 experts). Four experts pointed out that with a purely Chinese production of the NoMix toilets, the price would be much lower.

2.3 Perspectives for the implementation of the sanitation alternatives in the city

The estimated chances for present and future implementation of the sanitation alternatives are shown in Figure 8. According to this figure, the implementation of both sanitation alternatives is not considered feasible today with 90% estimating that they can only be “very little” or “not at all implemented”. 60% think that NoMix and only 35% estimate that dry toilets could be “much” or “very much” implemented after 20 years. After 100 years these numbers rise to 80% and 44% respectively.

Figure 8. Evaluation of the present and future implementation of the two different urine separating toilets

A little less than half of the experts (15 experts) think that public awareness will improve in the future and there is also a rather large minority (13 experts) that expect the technologies to become cheaper in the future, primarily due to technological improvement. Again the unsuitability of the dry toilets in an urban setting was mentioned (by 12 experts). Seven experts think, however, that lack of water or improved awareness could make such dry toilets an option also in an urban setting.

2.4 Preferences regarding the two sanitation alternatives

25 stakeholders out of 34 (74%) prefer the NoMix toilet over the dry toilet system. One representative from the real estate company does not want either of the alternatives and the rest (24%) favour the urine separating dry toilets. The main arguments do not differ from the arguments given above. However, valuable suggestions for the technical improvements of the dry urine diverting toilets were given (e.g. a combination of small household storage chambers and larger ones on the level of apartment buildings or the creation of public services for management), suggesting that locally driven innovation is possible.

5. Discussion

In the present study, we interviewed a large number of stakeholders from a variety of fields of expertise and with different positions in the decision making process. The topics of the interviews were measures at the source (MAS) in general for improving wastewater management in Kunming and more specifically two different versions of urine source separation.

The stakeholders agree to a large extent that measures at the source (MAS) are only little implemented in Kunming. Such measures are however well known and broadly favoured

amongst the stakeholders, albeit with a focus that in some areas differs considerably from the mainstream European attitude. Whereas the emphasis on MAS for industrial wastewater follows largely the European approach, the broad acceptance of MAS for toilet wastewater is striking. Equally striking is the fact that the importance of keeping non-polluted storm and river water out of the sewers is broadly questioned, in the quantitative and qualitative answers alike. It must however be mentioned that the stakeholder representing the Sewer Corporation and therefore directly involved in wastewater handling in Kunming shares the European view on non-polluted storm and river water (high priority and good feasibility for MAS) and on black water (low priority and very low feasibility for MAS; data not shown). We therefore conclude that the lack of interest in MAS for storm and river water is mainly a question of a large number of stakeholders not being familiar with the negative consequences of dilution on the effectiveness of wastewater treatment plants. In accordance with the perception in Europe, the topic of grey water was not considered of great importance.

At the moment we can only speculate why MAS for toilet wastewater come out that prominently. There are mainly three possible explanations. In the first place, the negative experience with the effectiveness of wastewater treatment plants despite remarkable efforts and large investments in the 1990s⁽³⁰⁾ may convey the picture that a stronger support of decentralized solutions for the concentrated waste streams would be appropriate. This support was already concretized with the 10th Five-Year Plan recently adopted by the government of Kunming where measures at the water pollution sources complemented the wastewater treatment enhancement and ecosystem rehabilitation plans.⁽¹⁹⁾ Secondly, the increasing water requirements in Kunming with its planned massive urban expansion⁽¹⁶⁾ highlights the dramatic situation of the lake and may therefore call for direct measures on all wastewater contributors. Even grey water recycling could be necessary in order to provide enough water and reducing the amount of wastewater discharged to the lake. Finally, the successful introduction of dry urine diverting toilets in rural areas of the neighbouring province Guangxi⁽³¹⁾ provides positive associations with such decentralized sanitation units.

The optimism of the stakeholders with respect to technological possibilities is remarkable. Within a relatively short time span (20 years), most of the stakeholders expect measures at the source to be widely implemented. This optimism is consistent in both parts of the interview, although the optimism gets less pronounced the more concretely the technological alternatives on urine source separation are presented (in part two). The scepticism is especially pronounced for the dry toilet which more than half of the stakeholders see as only little implemented even after 100 years (as compared to only 20 % for the NoMix toilet). This

indicates that the majority of the stakeholders are against the concept of a non-flushing toilet, whereas the NoMix concept finds a much larger support. There may also be a reliance on other decentralized alternatives like the septic tanks which are relatively frequent in Kunming, an option, however, that we did not pursue in the interviews. Still, we can conclude that measures at the source combined with a western style flushing toilet are highly favoured by the stakeholders interviewed.

The indication that political barriers are more important than technical barriers is rather weak (nine experts mentioning political barriers versus six experts mentioning technical barriers), but may be significant. In a previous work, we found that the few key political stakeholders are presumably the most important hurdle for introducing decentralized sanitation technologies in urban areas of Kunming. However, there is a general feeling that these key stakeholders could be influenced by successful pilot projects.⁽²⁸⁾

The difference between rural and urban settings is well captured by the interviews in part two. It is largely anticipated that an urban population will not accept the dry toilets and even the acceptance of a western-style NoMix toilet is considered problematic, albeit the high price may have unduly influenced the answers on acceptance (i.e. it was anticipated by the interviewees that people would not accept the high price). About two third of the population in the catchment area of Kunming are urban⁽³²⁾ and it will thus be essential to reach also the urban population with acceptable technology. Whereas the acceptance is considered higher for the NoMix toilet, a number of stakeholders also recognise that the environmental effect of the dry urine diverting toilet is better, because it deals with the entire amount of black water and not only with urine. In our opinion, we capture the wish for 'western-style' flushing toilets rather well with the option of the NoMix toilet although it is obvious that more comprehensive solutions are necessary in Kunming.

If dry toilets should be successfully installed in an urban context, the main problems of management, provision of ash and space required for this sort of toilets call for innovative technical and organisational solutions. Whereas a good management system would obviously involve a central collection system and at the same time be able to provide the necessary ash or other drying material, the space problem may be more difficult to solve. It is a question whether low-tech solutions with their dependence on space and time consuming processes will ever be adequate under the space-limited conditions found in large, modern cities like Kunming. The success, however, experienced in rural and peri-urban areas in China, obviously makes it worthwhile to invest in the further development of these systems in order

to adapt them to such an urban environment. The suggestions for improvement cited above show that local initiative is available.

6. Conclusion

In rapid growing cities like Kunming, decentralized technologies have a large potential of alleviating the problems of water pollution control. In problem-centred expert interviews conducted with 34 stakeholders concerned with the wastewater situation of Kunming, we found that most of those stakeholders generally approved of measures at the source, especially for industrial wastewater and toilet waste. There was however little awareness of the negative impact of dilution by river water and/or storm water on the effectiveness of central wastewater treatment, especially among stakeholders not directly concerned and experienced with wastewater treatment technology. Also the topic of grey water was not considered of great importance. However, the extreme situation in the catchment area of Dianchi Lake, the most important receiving water in the greater metropolitan area of Kunming, requires comprehensive solutions, probably including severe measures at the source, and possibly even grey water recycling

With respect to feasibility, today's technical solutions are considered inadequate, but there is strong and almost unanimous optimism among the different and diverse stakeholders, that the technology will be significantly improved within a relatively short period of 20 years. Optimism is largest for decentralized solutions combined with western-style flushing toilets. This is very remarkable and perhaps typical for the fast changing situation in China. Whereas the rapid expansion of the city poses a severe handicap for the development of centralized sewer-based wastewater management, it may constitute an excellent laboratory for the development of decentralized innovative solutions. Local initiative with respect to technical innovation is available and most of the stakeholders are open-minded.

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