Paper for the 7th IWA Specialist Group Conference on Waste Stabilization Ponds at the Asian Institute of Technology (AIT) in Bangkok on 25 - 27 Sept. 2006

Future Potentials of Wastewater Pond Systems

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Abstract

Wastewater treatment systems have to deal with current and upcoming challenges like growing population, increasing treatment requirements and limited water resources. Wastewater ponds offer many potentials to meet these demands, as shown for several aspects like technological upgrading, water reuse and wastewater disinfection.

Keywords: disinfection, developing countries, pond, reuse, upgrade, wastewater

Introduction

Treatment of wastewater by pond systems is a proven and (world-)wide spread technology. But like all treatment options, waste stabilisation ponds (WSP) have to cope with several current and future challenges like:

- growing population (particularly in developing countries),
- increasing restrictions in terms of environmental impacts,
  especially regarding wastewater effluent quality,
- need of wastewater reuse (because of limited resources),
- enhancing requirements regarding treatment and operational reliability,
  with limited competence of operation personnel at the same time,
- limited economic resources in many (but not only) developing countries.

Within this array of challenges - and in spite of their specific disadvantages - pond systems offer many potentials and options for sustainable solutions. Although pond systems have been in operation for decades, they are absolutely not old-fashioned. To show this, main future potentials and options will be described in this paper including following exemplary aspects:

1. „High brain - lean tech“ approach,
2. evolution / diversification of pond systems and combinations with other treatment systems,
3. stepwise extension options,
4. wastewater reuse and wastewater disinfection options,
5. wastewater treatment in developing countries,
6. decentralised wastewater treatment,
7. economic aspects.

1. The „High-brain - lean-tech“ approach

It seems to be a fact that, especially in developed countries, waste stabilisation ponds (WSP) often have the reputation to be too simple to be applied in highly developed surroundings. In addition to driving forces like increasing requirements for treatment quality etc., this phenomenon intensifies the situation described in figure 1: with the enhancement of the status of (technological) development, more “ambitious” treatment technologies become dominant and the simple treatment options lose shares (remark: the figure displays just a rough estimate, to show the general qualitative changes during the (chronological) enhancement of the stage of development, based on the author’s experiences).

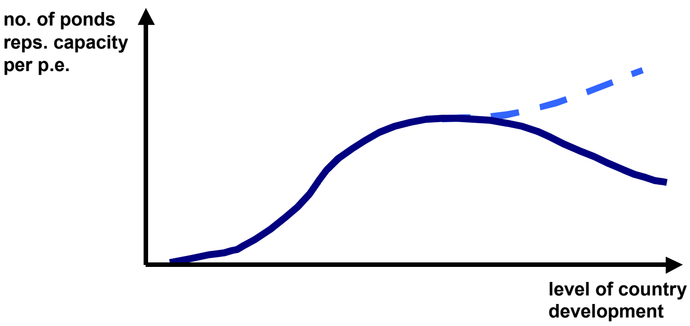

Figure 1:
Rough estimate of pond capacity per population equivalent referring to the stage of development

As an answer to the “low-tech” reputation, pond technologies should be updated by an approach, we may call “lean-tech”. In long term, such an approach will be necessary for the future developments of pond systems, with regards to at least following factors:

1. High-price industries will get a chance to find a ready market in the field of simple wastewater treatment processes like pond systems only by integrating intelligent “lean-tech solutions”.
2. Improvements in making pond systems more efficient, with respect to economical or ecological parameters, broader their field of employment, in particular in countries with high labour costs and effluent standards.
3. Because of the simple basic process, pond systems really lend themselves to upgrading by intelligent solutions.

The trend to more complex and sophisticated pond systems shown on former WSP conferences displays that the upgrading task is continuously under processing. As examples for lean-tech approaches, remote control and effluent disinfection by UV radiation may be mentioned.

As an example: The remote control option

Remote control systems are an excellent example for the above mentioned "lean-tech" solutions, which may let the control of decentralized pond plants become centralized. This makes ponds systems more reliable, even in countries with high standards regarding operational and process stability, but with high costs for staff to control the plants (in industrialized countries) or little resources of staff with the necessary competence (in some developing countries). As the operation of pond plants requires only few intervention by present staff, these systems offer ideal circumstances for remote control.

Figure 2:
Remote Control of a WSP plant
(Searchlike, USA; Photo by Rudolph)

2. Evolution / diversification of pond systems and combinations with other treatment systems

As a main share of presentations and activities on the current and former IWA-WSP conferences deals with this topic in terms of improvement and further development of the state-of-the-art pond technology, there is few more to add than an overall view of the options:

- enhancement of ponds systems, e.g. by adding recirculation systems or baffels, high-rate algal approaches, use of macrophytes etc.,
- combination of different types of pond like aerated, deep or shallow ponds, maturation lagoons, high-rate algal ponds etc.,
- combination with other treatment systems, like activated sludge tanks or trickling filters (as for example applied for the PETRO-system) or combination with membrane technology,
- linking with wetlands as a similar natural treatment technology.

Even relatively simple changes in the pretreatment of the influent or in the construction of ponds itself can improve the performance significantly. Last aspect is shown in figure 3 with the example of different pond profiles.

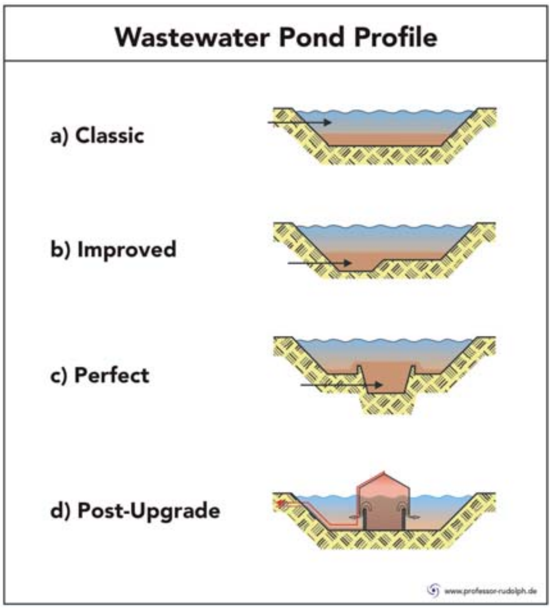

Figure 3:
Upgrading of pond performance by different pond profiles (Rudolph et al. 2006; pos. c): Meiring; pos. d): patents pending)

3. The stepwise extension options

Increasing technical and environmental regulations and standards in different countries as well as high population-growing rates, especially in developing countries, will result in future needs of upgradeable treatment systems. Particularly pond systems offer good conditions for such a stepwise extension and progressive upgrading - with upgrading in the sense of quantity as well as quality by adding separate treatment steps.

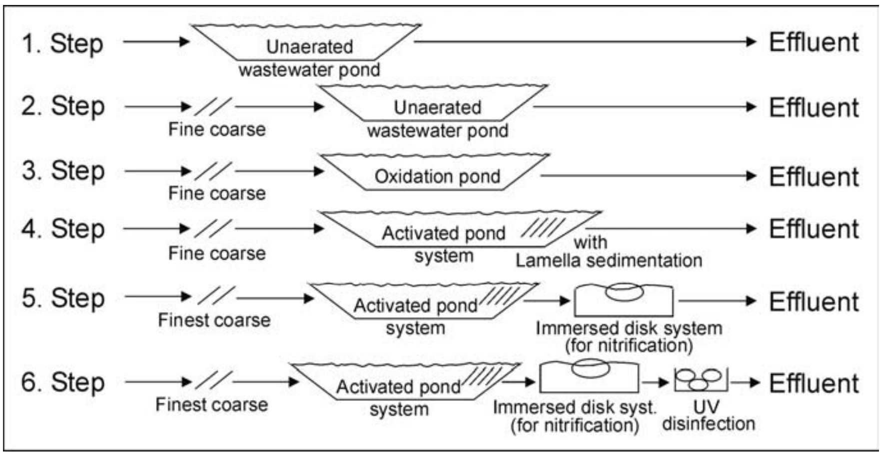

Figure 4:
Stepwise extension of municipal wastewater treatment plants based on pond systems (Rudolph, 2005)

Concrete examples are the integration of lamella separators, as shown in figure 4 (Rudolph, 2005), or the CWSBR process (Ruck et al., 2002). Both are technologies to improve existing pond systems by adding new elements into the ponds. The PETRO process, developed in South Africa (e.g. Meiring et al., 1998), is another example to increase the systems' performance by additional external treatment steps.

4. Wastewater reuse and disinfection options

As wastewater reuse for agricultural purposes is above all a topic in rural areas of developing countries, natural treatment methods like waste stabilisation ponds are a feasible option, because the high space requirements of pond systems are less significant in this cases.

When talking about agricultural wastewater reuse, appropriate wastewater disinfection is the main objective, unlike the reduction of nutrients, which are often used as fertiliser. As typical raw sewage contains for example coliforms (total) of between 10,000,000 to 10,000,000,000 per 100 ml, reuse and reclamation of wastewater require a significant reduction of pathogens in the effluent. Pond systems offer excellent treatment features in terms of physical and biological reduction of pathogens in faecally-contaminated wastewater. Even standard WSPs, not especially designed for pathogen reduction, may achieve a reduction rate of at least three logarithmic steps (see example in figure 5). The reduction rate depends on different aspects like depth, sedimentation, pH value and temperature.

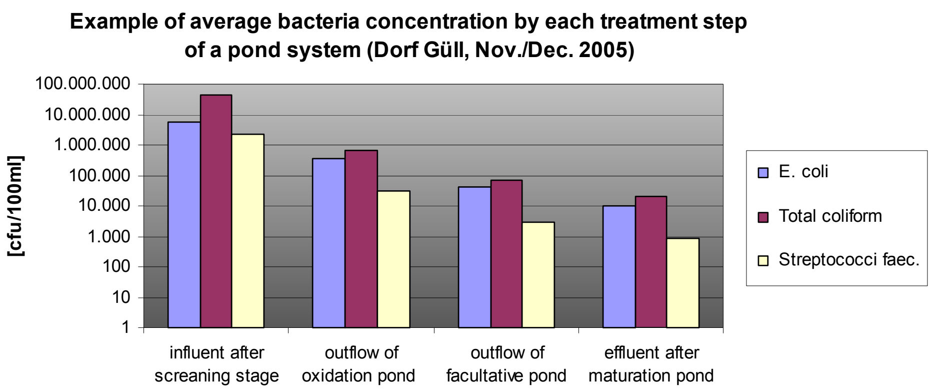

Figure 5: Example of pathogen reduction in a three stage WSP

Despite the significant disinfection effects in pond systems, the effluent is seasonal variable and regularly does not fulfil relevant microbiological quality requirements like the WHO standard for wastewater reuse (like other mechanical and biological treatment systems, too). This results in the need for supplementary treatment of WSP effluents, which means the use of post disinfection systems. There exist a number of disinfection options for WSP effluents, as compared in table 1 (partly from Rudolph 2006).

The cheapest way to reduce pathogens can be achieved by chlorination, but this method has the disadvantages of dangerous handling and the formation of harmful chlorinated organic by-products. Ozone and membrane systems both are characterised by difficult handling as they need specific technical devices. UV irradiation is a relatively simple method but has been known as problematic in terms of the high solid content of WSP effluent, which results in low UV transmission rates.

Table 1: Comparison of supplementary disinfection options

	Handling	By-products	Costs
Chlorine gas (Cl_2)	--	-	++
Sodium hypochlorite (NaOCl)	-	-	+
Ozone (O_3)	-	(-)	-
Ultra-violett (UV) light	+		+
Membranes	-		-

Within a current research project, the author carried out own experiments with UV disinfection of pond-treated wastewater. As illustrated in figure 7 by examples of typical dose-response curves (obtained by using a collimated-beam device for laboratory tests, like displayed in figure 6), the reduction rate for pond effluent is somewhere between mechanically and advanced biologically treated wastewater.

Figure 6:
Collimated beam device for disinfection tests with UV irradiation

First results show that, although the disinfection efficiency is significant lower in comparison to fully treated wastewater, UV irradiation is a possible and reasonable disinfection method for wastewater, even without extended conventional wastewater purification and without post filtration or other forms of advanced treatment. More detailed results from ongoing laboratory tests of the author will be presented on the conference.

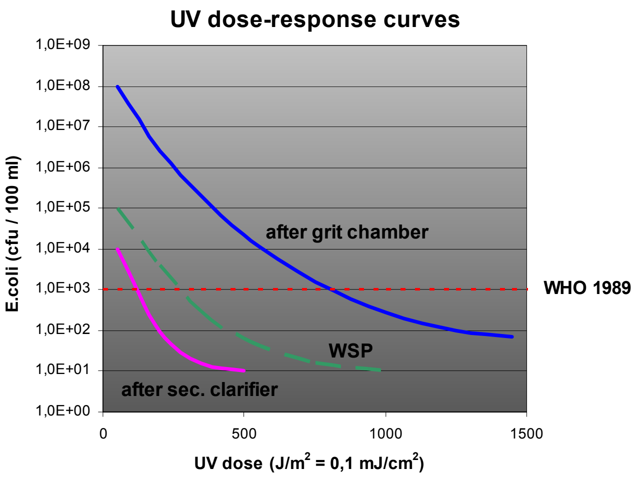

Figure 7:
UV dose-response curves for different treated wastewater

5. Wastewater treatment in developing countries

In several developing countries, only 10 % of all wastewaters are subject to purification (Homsi, 2000). Especially for rural areas in developing countries, wastewater ponds are generally the treatment process of first choice, because:

- pond systems are suitable for both small and large number of population equivalents (from <100 to >100.000),
- simple operation and maintenance (as the principal of the system is a mainly natural method of wastewater treatment),
- high performance regarding effluent quality,
- low capital and operational costs.

Not only to control river pollution, pond systems also can easily produce effluents of suitable quality for wastewater reuse in agriculture or aquaculture. The main specific disadvantage to require much more space than technical processes, such as activated sludge systems, often plays a minor role in rural areas.

Even for the special problem of the treatment of septic and faecal sludge concerning many developing countries, which do not have a sewerage system, pond technology offers in combination with other methods upcoming solutions to deal with.

6. Decentralised wastewater treatment

Striking up the prior point, application of pond systems is absolutely not limited to developing countries. High costs of centralised wastewater treatment systems for rural settlements drive a trend to more decentralised solutions - even in industrialised countries. Pond systems with low building and operational costs are an ideal and important element within this world-wide decentralisation trend.

7. Economic aspects

There are several kinds of waste purification systems available, but most of them are too costly to provide solutions for sewage water purification in growing developing countries (Grau, 1994). Due to relatively low construction and operational costs, pond processes offer opportunities for low-cost treatment of municipal sewage. As investment cost comparisons show, especially in rural areas the specific disadvantage of high place requirement per p.e. for pond systems plays a minor role, as the prices for land are relatively lower in comparison to that for necessary equipment of technical purification systems. In addition, the operation costs of WSP are generally lower than that of technical systems with higher requirements regarding maintenance and personnel competence.

Therefore, according to economic aspects, pond systems are an important solution for today's and future challenges in efficient wastewater treatment.

Summary

Wastewater treatment systems have to deal with current and upcoming challenges like growing population, increasing treatment and limited water resources. As described by an overview on future potentials and options, wastewater pond systems offer many approaches to meet the future demands. Especially in the field of wastewater treatment in developing countries or wastewater reuse for agricultural purposes, ponds offer many advantages, which let them stay a proven and innovative treatment technology of the future.

Acknowledgement

This paper is based on current research projects founded by the German Federal Ministry of Research (BMBF-FKZ 02WA0543, 02WA0569 and 02WD0757).

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