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Waste stabilization ponds: Past, present and future

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ABSTRACT

The 'past' of waste stabilization ponds (WSP) is due to early experience and design codes in the USA and also to two pioneering researchers, Oswald and Marais. The 'present' of WSP dates from the mid-to-late 1970s and is characterized by large numbers of full-scale systems in France, Germany and the USA. Research expanded greatly in several universities around the world, and much more is now known about pathogen and nitrogen removal in WSP, design procedures, WSP hydraulics and the benefits of baffling, and facultative pond effluent polishing in aerated and unaerated rock filters. Several design manuals, books and reference works have been published. The 'future' of WSP should see many more systems, including wastewater storage and treatment reservoirs, installed in both industrialized and developing countries, with pond/reservoir effluent reuse in aquaculture and agriculture, so making a large contribution to global food production.

Keywords: Waste stabilization ponds; History; Prospectives; Design; Research

1. Introduction

All of us at this conference know what waste stabilization ponds (WSP) are, but none of us knows everything about them as new research and new operational experiences are always extending our knowledge. We know that natural wastewater treatment systems, of which WSP are the best example, are more sustainable than electromechanical treatment systems, although we cannot always use WSP (for example, large cities, at least those in industrialized countries, are generally unserviceable by them), but we should always use them whenever we can. This means we have to 'sell' WSP more effectively than those who market electromechanical systems [1] or indeed those who passionately promote constructed wetlands [2–4]. Many, perhaps most, wastewater treatment engineers seem to have an in-built prejudice against WSP, but this is only due to ignorance, and ignorance can be 'cured' by knowledge transfer and experience. However, we still have to work very hard to remove these prejudices.

One 'selling' point that we need to make, and make continually, is that the choice between natural wastewater treatment systems and electromechanical systems is basically a choice between spending your money on land and spending it on electricity. Money spent on land is an investment (a good example is given by Oswald [5]), whereas money spent on electricity is money gone forever!

2. WSP: the past

The 'past' of WSP belongs mainly to early experience and design codes (such as the 'Ten States Standards') in the United States [6"9] and to two engineering professors in particular: Oswald in the USA and Marais in southern Africa (both of whom died in 2005). The work of these two WSP research pioneers is the basic foundation of the Present of WSP [5,10–16].

3. WSP: the present

The 'present' of WSP dates from the mid-to-late 1970s when France and Germany started to use WSP systems: by 1987 France had ~2000 WSP systems [17] and Germany ~1100 [18]. Currently there are >2500 WSP systems

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in France and ~3000 in Germany, including ~1500 in Bavaria alone, and in the USA ~7000 [19]. WSP are also used, but not in such large numbers, in many other industrialized and developing countries.

The present of WSP is characterized by much more research: large research WSP programmes continued during the present (e.g., at the University of California at Berkeley) and some were started during the present (e.g., at the Federal Universities of Minas Gerais and Paraíba in Brazil, Instituto Cinara at the University of Valle in Colombia, the Universities of Montpellier I and II in France, the Asian Institute of Technology in Thailand, Massey University in New Zealand, and the University of Leeds in England). Research results have been presented at the international WSP conferences organized by the WSP specialist group of the International Water Association and its predecessor bodies — the first of these was held in Lisbon in 1987 and the seventh in Bangkok in 2006. World Bank guidance on WSP in developing countries was issued in 1983 (and this still contains the best methodology for choosing between different wastewater treatment processes) [20]. Several WSP design manuals have been produced [19,21–25], as have reference works [26–30], and France produced an important review of its WSP experience [31]. The only real disappointment is the European Standard for "the performance requirements for the installation of lagooning processes" [32], which is not nearly as useful as the guidance document produced by the Environment Protection Agency of South Australia [33].

The major research highlights of the present of WSP are that we now know much more about (a) faecal bacterial removal mechanisms in WSP [34–36]; (b) WSP design for helminth egg removal [37]; (c) nitrogen removal pathways and mechanisms in WSP [38"40]; and (d) facultative pond performance in temperate climates [41]. Two other developments stand out: (a) a greatly improved understanding of WSP hydraulics and the resultant ability to design baffles rationally [25,42] — given that baffling has been shown to increase performance so dramatically, I would now consider it wrong not to baffle facultative and maturation ponds; and (b) the use of rock filters to 'polish' facultative pond effluents [43–46] — this use of rock filters is a significant advance as it means that maturation ponds are no longer always required (in contrast, rock filters are used in the USA to polish maturation pond effluents [47–50]).

Abis [41] found that a primary facultative pond loaded at ~80 kg BOD ha^{-1} d^{-1} produces an effluent which complies with the requirements for WSP effluents in the Urban Waste Water Treatment Directive (UWWTD), namely ≤ 25 mg filtered BOD l^{-1} and ≤ 150 mg suspended solids (SS) l^{-1} [51]. These requirements are quite lax and so may not satisfy all environmental regulators in the European Union, especially as they implement the Water Framework Directive [52]. It is here that aerated rock filters [43–46] become attractive: a small expenditure on energy not only greatly reduces land area requirements but also leads to much better performance in terms of BOD, SS, ammonia-N and faecal coliform removals — effluent concentrations of <10 mg BOD and SS l^{-1}, <3 mg ammonia-N l^{-1}, and <1000 faecal coliforms per 100 ml have been obtained at a hydraulic loading rate of 0.6 m^3 of facultative pond effluent m^{-3} of rock filter volume d^{-1} [Johnson, unpublished data].

4. WSP: the future

What of the 'future' of WSP? I see their future as very good. For small communities I see very simple WSP systems [53] as being necessary and implemented on a much larger scale than at present as engineers, prompted perhaps by public opinion that "natural" is better than "electromechanical", learn that WSP are not only low-cost and low-maintenance but also extremely high-performance. My view of a 'simple' WSP system suitable for small communities up to ~500 p.e. is that it should comprise a two-compartment septic tank [54] followed by a baffled secondary facultative pond and a rock filter, with the rock filter being aerated if ammonia-nitrogen removal is required [53]. For larger communities, up to ~2000 (the limit of 'small' in the UWWTD), an Imhoff tank can be used in place of the septic tank. (Septic and Imhoff tanks are recommended not only to protect the algae in the facultative pond, especially in winter, but also to facilitate desludging — no one worries about desludging these reactors, but inexperienced engineers often think that pond desludging every 10 years or so is just 'too big a task'.)

I do not share Oswald's vision of high-rate algal ponds (HRAP) being widely used in this century [55,56], simply because I do not believe that there will be a high demand for algal protein for use as animal feed ("sewage to beefsteak" [10]) — well, not in the next 25 years or so. In any case HRAP, as a treatment/algal-protein-production facility, are and will remain totally unsuitable for small communities.

However, I do believe that, as water scarcity increases (and increase it will — Fig. 1), the use of wastewater storage and treatment reservoirs (WSTR) [58,59] or hybrid WSTR–WSP systems [60] should be used on a much larger scale than at present, even for small communities, as wastewater use in agriculture [61] or small-scale horticulture becomes more commonplace in all parts of the world. Wastewater-fed fish culture [62–64], ideally prior to crop irrigation [65], will also become more common.

Reuse will become so important to feed the ~2.5 billion 'new' people arriving in the next 25–30 years that even conservative engineers will realise that 'wastewater is too valuable to waste' and that wastewater treat-

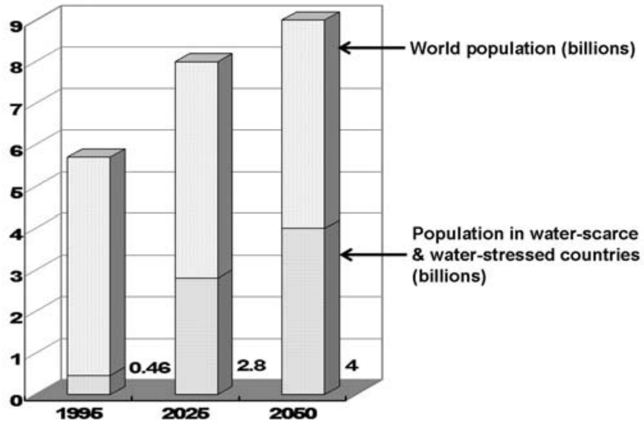

Fig. 1. World population and population in water-scarce and water-stressed countries, 1995–2050 [57].

ment in WSP and WSTR is an extremely reliable way to ensure the safety of the food so produced.

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