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# Interpreting best available technologies more flexibly: A policy perspective for municipal wastewater management in India and other developing countries

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ABSTRACT

Inadequate sanitation is amongst the causes of escalating pollution problems in developing countries, as municipal wastewater treatment systems remove only a fraction of pollutants that could be removed with best available technologies (BAT). Although BAT is a proven instrument of environmental policies, its potential for municipalities remains largely unused in developing countries. In order to ease its implementation, the paper developed a simplified assessment approach towards identifying an approximating of BAT in terms of a "flexible BAT" (FlexiBAT), which is based on the identification of national reference plants assessed with respect to pollutant removal (environmental impact, health impact), costs (economic viability, affordability) and social acceptability. The concept was tested for 58 case studies in India, where none of the technologies passed all tests for FlexiBAT. Therefore, there is a need to improve or develop better and more innovative technologies. Amongst the most promising ones, membrane bioreactors provided good physical water quality, but costs were high, while for moving bed biofilm reactors costs were low, but water quality was insufficient. Conventional onsite systems require separate consideration. In order to ease the identification of FlexiBAT, a national environmental information system with data from the regular monitoring of existing plants would be needed.

## 1. Introduction

### 1.1. Background

In India, 70% of sewage from cities remained untreated (UNICEF et al., 2013, for 2010). Economic losses from inadequate sanitation may slow down economic growth, as costs from pollution and health impacts were estimated as 6.4% of gross domestic product (UNICEF and WHO, 2010). In 2015, the Government of India responded with new water quality standards for wastewater treatment (WWT), defined in the 'Directions under the Water Prevention and Control of Pollution Act' (CPCB, 2015). These standards reduced previous thresholds for the effluents of sewage treatment plants (STPs) by factors from 3 to 10 (Table 1). These new standards were rigorous also by international standards (EPA, 2012). The urban local bodies (ULBs) were obliged to implement the new standards within five years, whereby they would have to build new systems or upgrade their old ones in order to meet the new requirements. As observed also in the present paper, such an obligation could overtask rural ULBs. Recently, the Government of India (Environment Protection Amendment Rules) restored the old thresholds for rural ULBs (GoI, 2017). However, also in rural towns all new infrastructure is now planned and tendered on the basis of the

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**Table 1**
Water quality criteria of India.

| Indicator | | Old | New[a] | Recently revised[b] | |
|---|---|---|---|---|---|
| | | | | Metro cities | Rural towns |
| Water clarity | TSS in mg/L (total suspended solids) | 100 | 20 | 50 | 100 |
| Organic pollution | $BOD_5$ in mg/L (biological oxygen demand) | 30 | 10 | 20 | 30 |
| | COD in mg/L (chemical oxygen demand) | 300 | 50 | Not mentioned | |
| Nutrient load | TKN in mg/L (total Kjedahl nitrogen) | 100 | 10 | | |
| | N as $NH_4$ in mg/L (ammoniacal nitrogen) | 50 | 5 | | |
| Pathogen load[c] | FC in MPN/100 mL (faecal coliforms) | 1000 | 100 | 1000 | |

[a] CPCB (2015).
[b] GoI (2017).
[c] MPN = most probable number method for colony count.

strict thresholds of CPCB (2015).

Similar responses to escalating pollution may be expected in other developing countries. In order to tackle pollution problems, best available technologies (BAT) may be needed also for municipal WWT, as aside from insufficient access to sanitation also the treatment efficiency of existing sanitation systems would be insufficient (Fuhrmeister et al., 2015). For ULBs it may be an economically sustainable policy to install BAT now, provided a technology with acceptable running costs can be found. For instance, currently most of the high construction costs are funded (Brunner et al., 2010), while in economically advanced developing countries the future funding of these upgrades may not be secured, if international donors shift development aid to more needy countries (Agrawal, 2013).

However, there are no legal reference documents for BAT in municipal WWT of developing countries. Existing regulations have an industrial focus and apply to industrialized countries with low ambient pollution, such as the USA (effluent guidelines under the Clean Water Act) or the member countries of the European Union (Industrial Emissions Directive 2010/75/EU, Integrated Pollution Prevention and Control Directives 96/61/EC and 2008/1/EC).

In order to prepare such reference documents, the status quo needs to be known. When the authors started the present research in 2012, there have been no systematic studies about the performance of STPs in India. As the Supporting Information outlines, also more recent studies differed in their focus and so their conclusion were not always comparable. Consequently, ULBs seeking guidance in literature were left alone. The present paper aims at closing this gap by providing them guidance in using experiences from other ULBs for the assessment and selection of technologies.

### 1.2. Problem of the paper

The paper asks, if policies of developing countries can and should aim at achieving BAT for municipal WWT, and if so, how this could be achieved. Therefore, in order to guide ULBs in the planning of WWT-systems, the paper does not aim at determining BAT as such, but in approximating BAT by developing and testing FlexiBAT, a simplified approach towards the assessment of municipal STPs with methods practicable for ULBs with low technical expertise. (However, some expertise will still be needed.) Other than BAT, which seeks the objectively best of the technologies used across the world, FlexiBAT aims at ensuring the viability for ULBs and it lets them compare the efforts of their peers. To this end, the paper proposes a benchmarking approach: For each relevant indicator, FlexiBAT identifies reference plants amongst existing STPs, considering also site-specific constraints (e.g. for land use). Amongst considered indicators are the quality of the treated waste water (TWW) with a focus on the environmental and health impact, costs (affordability) and social acceptance.

While this approach restricts the transferability of FlexiBAT-findings, the method as such generalizes. The paper illustrates it by an analysis of 58 case studies in India. The focus was on decentralized sanitation systems in rural areas, smaller towns and peri-urban areas. Indeed, in developing countries centralized WWT-systems would be costly to build and operate; also the technical expertise to manage and operate them may not be locally available (Massoud et al., 2009). By contrast, decentralized WWT may be a viable option, where policies of India have shown a supporting attitude (Alley, 2016, at p. 14).

## 2. Materials and methods

### 2.1. Methodological framework

The research for this paper was guided by the planning-oriented sustainability assessment framework (Starkl et al., 2013b). It aims at avoiding pre-fabricated solutions by guiding decision-makers in communicating on an equal footing with technical experts in order to identify solutions that give proper considerations to the views of all stakeholders. This framework appeared suitable for developing guidelines for urban local bodies (ULBs) that seek consensual solutions of their sanitation problems by utilizing the experience of experts and of other ULBs. Thereby, a major addition to conventional technology assessment is the consideration of social and institutional aspects and

**Table 2**
Workflow of the research.

| Phase 1 | Phase 2 | Phase 3 | Phase 4 | | Phase 5 |
|---|---|---|---|---|---|
| Preparatory work | Water quality (TSS, $BOD_5$)<br>Water quality (pathogens) | Water quality (more indicators & measurements) | Performance comparisons | Environmental impact | Overall assessment |
| | Reuse options realized | Sludge (quality)<br>Impact of reuse (e.g. soil) | | | |
| | Capital costs of STPs<br>Financing, user fees | Running costs | Affordability for users | Social acceptability | |
| | HH surveys (WTP, acceptance) | | | | |
| | Social criteria development | Focus groups (acceptance, working conditions)<br>Institutional aspects | Viability for decision makers | | |
| | Interviews (local politicians) | Stakeholder workshops (acceptance criteria) | | | |