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Review

Municipal wastewater effluent licensing: A global perspective and recommendations for best practice

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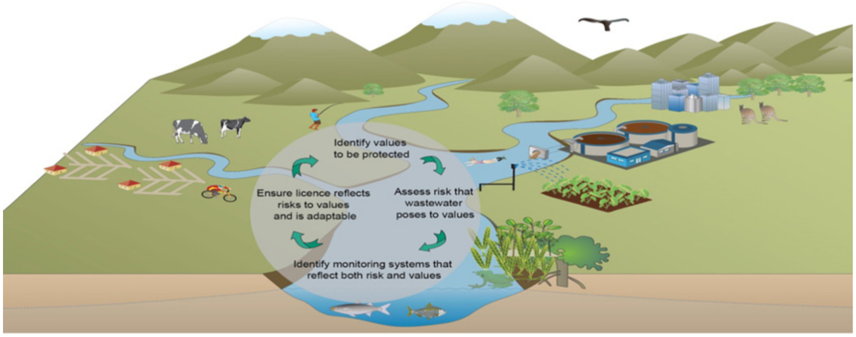
HIGHLIGHTS

- Emerging contaminants are not covered in current licensing regulations.
- Optimal treatment choices are catchment specific.
- Licenses must ensure there is no disconnect between core values and monitoring system.
- Adaptive wastewater licensing: value driven, context specific, informed by research.

GRAPHICAL ABSTRACT



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ABSTRACT

Advances in wastewater treatment have greatly improved the quality of municipal wastewater effluents in many parts of the world, but despite this, treated wastewaters can still pose a risk to the environment. Licensing plays a crucial role in the regulation of municipal wastewater effluents by setting standards or limits designed to protect the economic, environmental and societal values of waterbodies. Traditionally these standards have focused on physical and chemical water quality parameters within the discharge itself, however these approaches do not adequately account for emerging contaminants, potential effects of chemical mixtures, or variations in the sensitivity and resilience of receiving environments. In this review we focus on a number of industrialised countries and their approach to licensing. We consider how we can ensure licensing is effective, particularly when considering the rapid changes in our understanding of the impacts of discharges, the technical advances in our ability to detect chemicals at low concentrations and the progress in wastewater treatment technology. In order to meet the challenges required to protect the values of our waterways, licensing of effluents will need to ensure that there is no disconnect between the core values to be protected and the monitoring system designed to scrutinise performance of the WWTP. In many cases this may mean an expansion in the monitoring approaches used for both the effluent itself and the receiving waterbody.

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Contents

1. Introduction

Increasing urbanisation, industrialisation and population pressures have resulted in growing challenges in wastewater management globally (Allaoui et al., 2015). Discharge of municipal wastewaters to waterbodies has become an important disposal route, and recognition of the finite nature of our water resources (Dublin Principal No. 1, International Conference on Water and the Environment 1992) has led to increased governance of both wastewater and the receiving waterbodies. This has been followed by the recently adopted 2030 Agenda for Sustainable Development, Goal 6 which aims to ensure availability and sustainability of water for all (https://sustainabledevelopment.un.org/sdg6). Wastewater plants are designed to collect and treat domestic sewage and industrial trade wastes in such a way that the effluent should not compromise the ability of the receiving waterbody to support economic, ecological and societal values. Management options available where the plant is not meeting required standards include: increasing treatment technology; wastewater reuse; source control (e.g. reducing the contaminant load entering the plant); and behaviour controls (e.g. influencing the behaviours that are affecting contaminant loads which could include things like use of personal care products). Initiating these options depends on a suitable monitoring program that is able to demonstrate whether or not the plant is adequately protecting the values of the receiving environment and which can be managed through the issuing of discharge licenses.

Licensing is the foundation of most regulatory approaches to protect the values of aquatic systems (Xenarios and Bithas, 2012) and is used worldwide (see Table 1 for examples). The traditional approach to this type of regulation is known as 'command and control' and involves setting limits or providing standards relating to the quantity and quality of effluent being discharged to ensure protection of the receiving water body (Allaoui et al., 2015). Traditional license limits include an implicit assumption that the standards for nutrients, dissolved oxygen, heavy metals and bacteria protect the values of the receiving waters and failure to comply with license limits is usually met with a system of punitive measures, mostly financial. As our understanding of the potential impacts of complex effluents increases, along with our appreciation of the fact that sensitivity and resilience to pollution will vary substantially across ecosystems (Hering et al., 2010), it seems likely that traditional regulatory approaches to licensing may not be enough to meet all of these conflicting needs. While frameworks and recommendations exist for additional measures to be included in licenses in many countries (such as toxicity testing, biological monitoring, priority pollutants; see Table 1), it is often only traditional water quality measures that are present in the final license (EPA Victoria, 1995; Tinsley et al., 2004). These traditional water quality measures tend to be used throughout the world in basic license structures where regulatory limits may exist at both national and local levels e.g. India (CPHEEO, 2012) and China, although some pilot areas in China have also been trialling emission trading schemes (U.S. Department of Commerce, 2005). There are changes evident in parts of the world such as South Africa where new legislation under the National Water Act 1998 now stipulates biomonitoring in the effluent and the receiving waterbody in more sensitive areas (Eddy, 2003).

Adjusting treatment technology is a common response to repeated failure to meet license limits. Waste water treatment plants (WWTP) are designed to efficiently reduce or eliminate a wide range of substances, including particulates, nutrients and pathogens, which are frequently included in license limits. Wastewater treatment involves a primary, secondary, and in some cases a tertiary treatment process, which is based on mechanical, biological and advanced (often chemical) treatments respectively. Secondary treatment is the most common treatment standard in Europe, North America and Australia (Table 1) and is based on application of biological processes that degrade a variety of organic compounds that are not eliminated during primary treatment (Fig. 1) (Luo et al., 2014; Wahlberg et al., 1994). These processes are generally effective at reducing nutrient concentrations and also remove a higher percentage of emerging contaminants than primary treatment, however the removal efficiency of emerging contaminants can be inconsistent and inadequate (Luo et al., 2014; Bolonga et al., 2009; Siegrist and Joss, 2012; Verlicchi et al., 2012). In addition, some contaminants may be transformed back to parent compounds during secondary processes or broken down into products as toxic as the parent compounds which are not further processed before discharge (Cirja et al., 2008; Matamoros et al., 2016).

Tertiary treatment processes are employed to produce higher quality effluent prior to discharge to the receiving environment. Although definitions vary considerably (see for example Davis, 2010; Hopcroft, 2014) tertiary treatments are generally mechanical or chemical based and include processes such as post ozonation and advanced ozonation, filtration (nano, micro, sand), reverse osmosis, activated carbon adsorption (GAC, PAC), coagulation-flocculation, UV and chlorination (Fig. 1; Luo et al., 2014; Siegrist and Joss, 2012).

Although an increased level of treatment can reduce the risk of an impact on significant values of a waterway, the risk associated with a specific effluent will depend on a variety of factors. The composition and origin of the influent will impact on the types of pollutants present, and therefore the risk posed by the effluent. Understanding the key risks allows for the most appropriate type of tertiary treatment to be installed, and while no specific technique will provide complete