Sanitation in the pan-European region

Draft summary of findings of a scoping study

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DEFINITIONS

For the purpose of this report, the following regional categorizations were used:

- **Pan-European region**: The United Nations Economic Commission for Europe (UNECE) and World Health Organization (WHO) Regional Office for Europe define 54 countries[1] in Western Europe, Eastern Europe, the Caucasus, Central Asia and Israel.
- **Western Europe**: Andorra; Austria; Belgium; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Iceland; Ireland; Italy; Latvia; Liechtenstein; Lithuania; Luxembourg; Malta; Monaco; Netherlands; Norway; Poland; Portugal; San Marino; Slovakia; Slovenia; Spain; Sweden; Switzerland; United Kingdom.
- **Eastern Europe and Central Asia**: Albania; Armenia; Azerbaijan; Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Georgia; Kazakhstan; Kyrgyzstan; Montenegro; Republic of Moldova; Romania; Russian Federation; Serbia; Tajikistan; the former Yugoslav Republic of Macedonia; Turkey; Turkmenistan; Ukraine; Uzbekistan.

For describing sanitation service levels, the service ladder categories were used, as proposed by the WHO/United Nations International Children's Emergency Fund (UNICEF) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP):

- **Safely managed service**: Use of improved facilities, which are not shared with other households and where excreta are safely disposed in situ or transported and treated off-site
- **Basic service**: Use of improved facilities which are not shared with other households
- **Limited service**: Use of improved facilities shared between two or more households
- **Unimproved service**: Use of pit latrines without a slab or platform, hanging latrines or bucket latrines
- **Open defecation**: Disposal of human faeces in fields, forests, bushes, open bodies of water, beaches and other open spaces or with solid waste

[1] See https://www.unece.org/oes/nutshell/region.html and http://www.euro.who.int/en/countries

INTRODUCTION

Safely managed drinking water and sanitation services are essential for health, well-being and clean environment in communities. Often these services are taken for granted and remembered only when something goes wrong.

The pan-European region failed to reach the Millennium Development Goal (MDG) target 7C to halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation. The 2030 Agenda for Sustainable Development provides a strong mandate for addressing sanitation by broadening the focus of attention from mere access to improved sanitation to looking at the entire sanitation cycle. Sustainable Development Goals (SDGs) call to:

- "*ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as* ***access to basic services*** *[…]*" (SDG target 1.4);
- "*achieve access to adequate and* ***equitable sanitation and hygiene for all*** *and* ***end open defecation****, paying special attention to the needs of women and girls and those in vulnerable situations*" (SDG target 6.2);
- "*improve water quality by reducing pollution […],* ***halving the proportion of untreated wastewater*** *and substantially increasing recycling and* ***safe reuse*** *globally*" (SDG target 6.3).

Globally, as of today,

- 6 in 10 people lack access to safely managed sanitation facilities;
- 892 million people continue to practice open defecation;
- 4 billion people lack access to basic sanitation services, such as toilets or latrines; and
- More than 80% of domestic wastewater is discharged into rivers or sea without any treatment.

This results in millions of people, including children, suffering from diseases associated with inadequate water supply, sanitation and hygiene.

The objective of the scoping study is to review the status of sanitation in the pan-European region, which covers an area of about 28 million km^2 with a population of 920 million, and to identify gaps and priorities for policy and technical action under the UNECE and WHO Regional Office for Europe Protocol on Water and Health. The study focuses on wastewater collection, treatment, disposal and reuse practices, sanitation policies, as well as the impacts on health and the environment.

The present summary of preliminary findings of the scoping study, prepared by an independent consultant and the Netherlands National Institute for Public Health and the Environment (RIVM), contains selected data and highlights based on a systematic review of scientific and grey literature.

Participants of the Workshop on sanitation in the pan-European region (Bonn, Germany, 12–13 February 2019) are invited to provide feedback on the structure, content and completeness of the document, suggest inclusion of additional data and policy references and point out to gaps and potential information sources.

METHODOLOGY

Information for the study was collected by undertaking a systematic review of grey (non-academic) literature and scientific literature covering the pan-European region. The present document summarizes preliminary findings of the review.

The following priority sources were analyzed: UNECE Environmental Indicators, UNECE Environmental Performance Reviews, WHO/UNICEF JMP, UN-Water Global Analysis and Assessment of Sanitation and Drinking-water (GLAAS), World Water Development reports, European Environment Agency (EEA) data, Food and Agriculture Organization of the United Nations (FAO) Aquastat, Organization for Economic Co-operation and Development (OECD) data, national and EU policy/working documents, national summary reports under the Protocol on Water and Health and reports of development agencies. Additional sources were identified covering national, regional and global data and reviews.

A scientific literature search was performed for relevant key words in the EMBASE database in July 2018. To determine relevance, a total of about 1 600 articles were screened by title, abstract and methods sections according to predetermined inclusion/exclusion criteria. Studies were included if they could link contamination to any form of sanitation, were in the pan-European region and mentioned either human health risk and/or environmental impact/risk. This led to a total selection of 334 relevant articles. These were screened manually and additionally in-depth by using text mining methods, performed with the *R scopus* package made available through the open source modelling software R (https://www.r-project.org/). Pattern matching was used to automatically assess which contaminant classes, treatment options and countries were investigated in the analyzed articles.

In addition, 16 selected countries (Bosnia and Herzegovina, Finland, France, Georgia, Italy, Kyrgyzstan, Lithuania, Malta, Netherlands, Republic of Moldova, Romania, Serbia, Slovenia, Spain, Tajikistan and Ukraine) were subject to a detailed review through a survey questionnaire. The questionnaire results are currently being processed and are not reflected in this document.

HIGHLIGHTS

- Poor sanitation practices and inadequate wastewater management may impact human health and the environment. Providing access to basic and ultimately safely managed sanitation services across the whole sanitation chain is crucial for public health and the environmental protection.
- Investment in sanitation is cost-effective. WHO estimates that every $ 1 invested on improving sanitation brings an economic return of $ 5 by keeping people healthy and productive.
- Poor sanitation costs the global economy over € 195 billion due to mortality, productivity loss and healthcare expenses, although the pan-European region is generally less affected – less than 4% of the above figure.
- Open defecation is still being practiced by 330 000 people in the pan-European region. These people are denied the opportunity to live in a healthy environment.
- Improving access to sanitation services remains a priority for the countries of the pan-European region. About 38% or 344 million people in the region do not have access to safely managed sanitation services; alone in Eastern Europe and Central Asia, 67% or 279 million people do not have access to such services. Access to basic and safely managed services increased globally by 10% during 2000-2015, while improvement in the pan-European region was less than 4%.
- Urban populations represent 76% or 370 million people of Western Europe, out of which approximately 29 million persons do not have access to safely managed sanitation services. Urban population in Eastern Europe and Central Asia represent 65% or 269 million people; out of those 43% do not have access to safely managed sanitation services.[2]
- Providing centralized wastewater treatment to sparsely populated areas is costlier as compared to provision of such services in larger cities, due to high wastewater collection and transport costs. Therefore, using decentralized wastewater treatment plants appears necessary for many parts of the pan-European region.
- Wastewater reuse opens access to new sources of water, nutrients and energy. The wastewater and sludge reuse in the pan-European region varies a lot. In the European Union (EU), for example, less than 3% of the treated wastewater was reused in 2017, while Israel reused around 90% of the generated wastewater. Reuse needs to be well planned and safely managed to prevent adverse impacts on human health and the environment.
- Climate change is expected to lead to higher and more frequent precipitation events. This implies the need for conversion of combined sewers into separate sewers, which would reduce overflows of untreated wastewater and urban flooding. These considerations will increasingly impact infrastructure investment needs in the pan-European region.
- Wastewater reuse opens new sources of water, nutrients and energy. Well-planned and well-implemented reuse concepts, supported by appropriate legal frameworks, can contribute to addressing water scarcity and provide opportunities in the circular economy context. However, reuse needs to be safely and sustainably managed to prevent adverse impacts on human health and the environment.
- A survey among selected countries in the pan-European region reveals that most countries have legislation addressing sanitation and especially wastewater treatment. However, enforcement is frequently hampered in countries in Eastern Europe and Central Asia due to lack of financial resources and qualified personnel.
- The aging sewer infrastructure represents an additional challenge in the pan-European region. The EU estimated that it will be necessary to invest about € 25 billion annually to rehabilitate and construct new sewers and wastewater treatment plants. Consolidated figures for Eastern Europe and Central Asia are not available but are likely to illustrate an even higher need.

[2] Figures are excluding Israel, as per definition of sub-regions.

SELECTED DATA

Access to sanitation

In 2015, about 96% of the pan-European population enjoyed access to basic sanitation services (in accordance with SDG target 1.4), while only 67% (279 million people) used safely managed sanitation services (in accordance with SDG target 6.2). Approximately 10 million people (1%) in the pan-European region used limited sanitation services and around 26 million (3%) relied on unimproved sanitation, while 330 000 people still practiced open defecation.

Urban populations represent 76% (370 million people) of Western Europe, out of which approximately 29 million persons did not have access to safely managed sanitation services. Urban population in Eastern Europe and Central Asia represent 65% (269 million people), where 43% (115 million people) did not have access to safely managed sanitation services.

Access to basic and safely managed services increased globally by 10% during 2000-2015, while improvement in the pan-European region was less than 4% (i.e. improving from 63% to 67%) and in Eastern Europe and Central Asia around 1% (i.e. improving from 31% to 32%).

Wastewater collection and treatment

In the pan-European region, 76% (685 million people) of the total population was reported to be connected to centralized sewer systems in 2015. The connection of households to sewers across the pan-European region increased by 4% during the period 2000-2015. During this period, septic tank usage reduced by 1% and the total population served with sewers, septic tanks and other improved systems increased from 93% to 96%.

In terms of connection to centralized sewer systems, there is a significant difference between Western European (90%) and Eastern European and Central Asian countries (62%). There is also as significant gap in connection to centralized sewer systems between urban (89%) and rural areas (45%) in the pan-European region.

While the urban population in Western Europe has the highest connection rates to sewers (95%), in Eastern Europe and Central Asia connection rates are lower (71%). More than half of rural dwellers (64%) in Eastern Europe and Central Asia rely on other forms of sanitation such as improved latrines and septic tanks.

While almost all wastewater from agglomerations over 2 000 persons is centrally collected in Western Europe, in Eastern Europe that share is only about 60%. In Western Europe, the wastewater collected from 87% of the population is treated to reduce organic matter and, in many places, to minimize nutrient content; in Eastern Europe and Central Asia only 32% of the collected wastewater is treated before discharge to the environment.

The aging sewer infrastructure represents an additional challenge in the pan-European region. Currently, existing sewers can be up to 50-100 years old and may require rehabilitation in the short- or mid-term. The EU estimated that it will be necessary to invest about € 25 billion annually to rehabilitate and construct new sewers and wastewater treatment plants. Consolidated figures for Eastern Europe and Central Asia are not available but are likely to illustrate an even higher need.

Reuse of wastewater

SDG target 6.3 sets a favourable context for substantial increase of recycling and safe reuse, while tackling water quality and quantity challenges and food security issues. Current wastewater reuse practices include reuse of water after appropriate advanced treatment and reuse of sewage sludge for agricultural purposes.

By 2030, low to medium water stress and scarcity is expected to affect half of the pan-European water basins, enforcing consideration of water reuse as an alternative source. In some densely populated parts of the region, there is a mismatch between water resources demand and availability, particularly in Southern Europe.

In the EU, less than 3% of the treated wastewater was reused in 2017 (i.e. 964 out of 40 000 million m^3). This is relatively low in comparison with, for example, Israel where they reuse roughly 90% of the generated wastewater. In 2017, 537 water reuse schemes were identified in Southern Europe as compared to 250 in Northern Europe. Information on water reuse in regions outside of the EU and Israel is scarce. Available information, however, suggests that reuse is not practised at scale.

In 2009, a comprehensive overview of wastewater sludge reuse was conducted for EU member states. By 2008, the total quantities of sludge in the EU were estimated at about 10 million tons (dry solids). Nearly 40% of this was estimated as spread on land for agricultural use, while a few EU countries used even more than half of all sludge production in agriculture. In several EU Member States, however, less than 5% sludge was recycled to agriculture.

IMPACTS

Health

Poor sanitation practices may lead to microbiological and chemical contamination of surface water and groundwater. Microbial contamination may lead to infectious disease due to drinking-water and recreational water exposures. Health effects can also be caused by chemical contamination of sources used for drinking-water abstraction.

Microbiological contamination of surface waters was found across the pan-European region, including contamination with *Escherichia coli*, *Cryptosporidium parvum* or norovirus. Wastewater treatment plants were frequently identified as a major source of contamination. There were also incidents in which groundwater abstraction wells were contaminated by small-scale onsite wastewater treatment systems which were not managed properly. Untreated storm water due to overflows and floods during extreme rain events represent an additional threat as they may pollute both surface and ground water sources.

Many chemicals that are being used by humans for personal hygiene or medical purposes enter the environment through human excreta. In many high-income countries, wastewater treatment plants are the main source of compounds such as pharmaceuticals and personal care products; municipal wastewater may contain a broad spectrum of chemical contaminants in settings where commercial entities discharge their wastewater in urban sewerage systems. Contaminants reaching the aquatic environment can cause both short-term and long-term disturbances to the aquatic ecology, but may also be of health concern if surface water is used for drinking-water production.

Water reuse may increase availability of water in a community and thereby positively impact its economic, social and environmental sustainability, also benefiting in better community health and well-being. On the other hand, the protection of public health is a key concern to water reuse. Without proper management, pathogens from wastewater can cause disease among those who work and live on or near the land where the water is being reused, and those who consume or handle the foodstuff contaminated from wastewater use. Pathogenic bacteria, viruses, protozoa and helminths present in wastewater have potential to persist in the environment and reach the agricultural field.

Health concerns may also be associated with chemicals that are present in recycled water and sewage sludge, including emerging contaminants such as endocrine disrupting chemicals, pharmaceuticals, disinfection by-products and their complex mixtures. However, there is limited toxicological and epidemiological evidence on the actual health effects of such substances as a result of wastewater use in agriculture.

Emerging contaminants is a widely used term for both chemical and microbiological contaminants. The term emerging could not only encompass contaminants which have only appeared recently but could also be contaminants of emerging concern (which have been in the environment for a while but for which concerns have been raised) or contaminants for which new information has been found that increased concerns. Although the term emerging itself is quite clear, the criteria to consider a microbiological contaminant or a chemical contaminant as emerging are very different.

The most important criteria for microbiological contaminants to become emerging are for example an expanded geographical and host range, an increased incidence and a recent discovery or recognition of the contaminants. Only one criterion has to apply in order to make the microbiological contaminant emerging. A microbiological contaminant can also be re-emerging, in case of a deteriorating sanitation situation, like for example *Vibrio cholerae* which reappeared in the 1990's in the USA.

Chemical contaminants are only emerging when multiple criteria apply. The most important criteria for these contaminants are being recently detected in the environment, being unregulated and being a potential threat to the environment and living organisms.

Environment

Unimproved sanitation and open defecation as well as partially or non-treated domestic wastewater can have serious impact on the environment, such as eutrophication, accumulation of solids, litter, harmful substances and presence of micropollutants. A consequence may be water use deterioration, for example, water supply, fishery, agriculture, recreation and bathing. Nutrients (nitrogen and phosphorous) in

domestic sewage may accelerate algal blooms in lakes and rivers, contributing cause oxygen depletion. Even in areas with good centralized sewer coverage, leaking sewers due to aging and faulty connections as well as overflows and flooding during extreme weather events may transport pollutants to water resources leading to environmental threats. They may also pollute the soil layers. Lack of proper sanitation and inadequate collection and treatment of wastewater may therefore cause not only health impacts but also environmental impacts, which in turn may cause secondary impacts on human health.

Water reuse is an emerging trend. Since it requires extensive purification of wastewater in most cases, it has the potential to greatly reduce or eliminate pollution of the aquatic environment. Irrigation or other land application of reused water can increase the volume of water into an ecosystem. On the other hand, multiple cycles of reuse of wastewater may lead to accumulation of certain less-biodegradable pollutants in the aquatic environment. Such concentration may be harmful to the environment and human health since most existing treatment plants are not optimized for the removal of these pollutants.

Climate change

The majority of drainage systems in the pan-European region are combined systems, which collect wastewater and rainwater in the same sewer. Due to cost restraints, combined sewers cannot be dimensioned to cater all precipitation events. This is especially a challenge with regard to covering increased and more intense precipitation events due to climate change. Consequently, these dimension restraints result in more frequent sewer overflows and transport of water containing untreated wastewater to lakes and rivers. Such events are called storm water overflows, and about 100 000 overflow structures were reported from 19 Member States in the EU in 2015. Data from other parts of the region are not available.

Climate change is expected to lead to higher and more frequent precipitation events. This implies the need for conversion of combined sewers into separate sewers, which would reduce overflows of untreated wastewater and urban flooding. These considerations will increasingly impact infrastructure investment needs in the pan-European region.

Economy

WHO estimates that every $ 1 invested on improving sanitation brings an economic return of $ 5 in the form of saved healthcare costs, welfare gained due to reduced loss of productive days and reduced loss of lives.

In 2015, poor sanitation costed the global economy over € 195 billion due to mortality, productivity loss, healthcare expenses etc. The pan-European region is generally less affected – since the estimates show that less than 4% of the above costs originate in Eastern Europe, Central Asia and Middle East combined.

Water reuse can increase the water available for community use, meeting demands for irrigation, while reducing the need to expand centralized water utilities. Communities may experience an increase in long-term economic sustainability as a result of increases in water availability.

At the same time, the economic feasibility of reuse projects is often unclear, due to costs of energy, installation, operation and maintenance of infrastructure and equipment, and disposal of waste by-products. Reuse systems can cost more to install than other conservation strategies, depending on the circumstances, because of the new infrastructure required, but planning for reuse in new developments and in tandem with infrastructure upgrades can help reduce costs.

POLICIES

Sanitation

A survey among selected countries in the pan-European region reveals that most countries do have legislation on sanitation. However, the implementation is still lagging behind in the majority of countries of Eastern Europe and Central Asia due to lack of financial resources and qualified personnel. All countries in the region, which are a Party to the Protocol on Water and Health, have included targets related to the improvement of sanitation.

Wastewater treatment

The majority of countries in the pan-European region have in place legislation on wastewater treatment. In the EU, for example, collection, treatment and disposal is regulated by the Urban Wastewater Treatment Directive (UWWTD), which requires that all agglomerations with a size of more than 2 000 population equivalents are equipped with collection and treatment systems for their wastewater. The UWWTD requires biological wastewater treatment (secondary treatment) to reduce biodegradable matter in wastewater. In the so-called sensitive areas (i.e. those areas suffering from eutrophication or used for other purposes, such as bathing or drinking water abstraction), more stringent treatment is required to eliminate nutrients (mainly nitrogen and/or phosphorus). Many of the neighbouring EU countries report approximation to the EU directives in their national legislation.

Wastewater reuse

At the level of international standards, ISO has published guidelines on the use of treated wastewater for irrigation in 2015, while keeping other reuse-related ISO standards under consultation. WHO offers health-based recommendations in its 2006 Guidelines for the safe use of wastewater, excreta and greywater.

The EU has introduced several instruments to promote water reuse in a circular economy context, including the Guidelines on Integrating Water Reuse into Water Planning and Management in the context of the Water Framework Directive and Best Available Techniques Reference Documents under the scope of the Industrial Emissions Directive.

Concerning reuse of wastewater sludge, the EU has recently launched several thematic consultations on the reuse of nutrients from biosolids in agriculture. Nevertheless, most countries of the pan-European region, including some EU countries, report the lack of good wastewater and sludge reuse legislations. The lack of qualified personnel is reported as an important factor.

Implementation

Implementation in terms of improving access to sanitation and wastewater treatment is frequently reported in the national summary reports under the Protocol. Such reporting is much more stringent and systematic for wastewater treatment in EU countries. Considering the requirements of collection, most EU member states achieved the maximum compliance rate of 100% regarding wastewater treatment. The provision of secondary treatment shows that most EU member states achieved very high compliance rates of more than 90% over the past years. Finally, the provision of more stringent treatment shows that 12 EU member states achieved high compliance rates above 90%.

Economical capacity

Most Eastern European and Central Asian countries indicate the lack of financial resources as one of the main challenges to achieve ambitions related to sanitation access and wastewater treatment. Although EU member states also report it as a challenge, they are more optimistic about accessing required financial resources. Their investment plans include estimates needed for extension and renewal of existing systems. These show that yearly investment rates will continue to increase by 14% compared to the current situation, reaching an average cost of almost € 25 billion a year.

HIGHLIGHTS OF THE WHITE LITERATURE REVIEW

The preliminary conclusions of the white literature review can be grouped in four categories:

- Detection studies;
- Implementation studies;
- Impact on human health;
- Impact on the environment (ambient water quality, plants and animals).

Some general conclusions include:

- Many of the studies are concentrated in the south-western and southern Europe;
- There is a focus on pharmaceuticals and emerging contaminants in the region since 2007;
- Sanitation-related outbreaks (1%) and antimicrobial resistance (AMR) (1%) are either scarcely researched or not submitted as papers for peer-reviewed journals.
- On-site sanitation is sparsely studied (5% of all papers), while the grey literature review based on the JMP showed that at least 20% of the population in the pan-European region is making use of on-site sanitation systems.

Detection studies

- In general, chemical pollutants were studied more than microbiological contaminants. Only 24% of all studies researched microbial contamination, whereas 31% of all papers deal with pharmaceuticals alone. There were several studies that researched both chemical and microbial contamination at the same time.
- Microbial water contamination due to wastewater discharge was found in countries all over the pan-European region, ranging from *E. coli* to for example *Cryptosporidium* or norovirus. The countries with the highest number of case studies involving **microbiological contamination** in the environment due to sanitation are Spain, Italy, Germany and Finland
- Bacteria are the mostly studied microorganisms in relation to sanitation (63%) whereas parasites where only studied in 14% of the papers studying microbial contamination.
  - *E. coli*, being the primary fecal indicator, was found in 35% of the all studies on microbial contamination.
  - Of the viruses, research on enteroviruses and norovirus were most commonly studied (n=14 and n=13, respectively). Italy was the country of which most papers were found on viruses (n=9), followed by Spain (n=6) and Finland and France (n=5).
  - Of the protozoa, research on *Cryptosporidium* oocysts (n=20) and *Giardia* cysts (n=17) was most common. Dominant research on this came from Spain (n=7), Italy (n=3), the Netherlands (n=2) and Romania (n=2). Helminths were the most often mentioned parasites (n=9).
- Of all **chemical contaminants** in the region, pharmaceuticals are the most widely studied compound class in 31% of the papers, followed by drugs of abuse (9%), micropollutants (5%) and phthalates (4%).
- Most papers describing the effect of sanitation (wastewater discharge) on pharmaceuticals detected in the environment are studies from Spain, Italy and Germany.
- An important focus in scientific literature is research on **'emerging' contaminants** (see also textbox). In the pan-European region, 83 papers (25%) describe 'emerging contaminants'. Most of them (n=79) focused on emerging chemical contaminants. Of the emerging chemical contaminants, pharmaceuticals and personal care products were the dominant group of

contaminants, followed by drugs of abuse and fragrances. Only 4 papers described case studies on emerging microbiological contaminants (1%), being viruses (n=2) and bacteria (n=2).

- Of the pan-European countries, most papers focussing on emerging contaminants described case studies in Spain (n=23), followed by France (n=4), the UK (n=3) and Italy, Germany and Greece (n=2 for all three countries).
- While AMR is a topic receiving much attention by the international health community (including WHO), studies on AMR genes and their behavior only represented 3% of all studies that were reviewed. This could lead to a careful conclusion that AMR in the environment, which can be attributed to wastewater discharges, is a scarcely studied subject.

Implementation studies

- There seems to be no general consensus on what comprises tertiary and advanced treatment; some consider mainly the timing in the sequence (as a last step), others the actual treatment process (disinfection, advanced nutrient removal, chemical removal).
- Studies on reuse applications mainly originated from Southern Mediterranean countries, while a review by Amoah et al. (2018) and the grey literature on the subject would indicate that there are more reuse pilots and practices in the region. This leads to the conclusion that this is an underreported/understudied subject for many research institutions in the region.
- One of the more relatively more studied subjects (4%) with regard to advanced treatment was the production recovery of phosphorus and energy. Advanced treatment is also understood in terms of process optimization in terms on energy savings and reduced greenhouse gas emissions, which have less to do with treatment efficacy for pollutants.
- There were several studies on septic tank system (5%) also referred to as on-site sanitation (n=18).

Impact on human health

- Investigations on outbreaks comprised a very small number of papers found in this review (only 1%).

Impact on the environment

- Chemical contaminants such as pharmaceuticals are discharged into the environment and lead to known and unknown (as depicted by high RQs) effects for ambient water quality (e.g. plants and animals).
- Organic compounds may lead to eutrophication and consequently ecosystem services and biodiversity loss.
- Chemical compounds with largely unknown mixture effects were found in water used to produce drinking water.