The Director General

Maisons-Alfort, 30 March 2012

OPINION
of the French Agency for Food, Environmental and Occupational Health & Safety

on "the reuse of treated wastewater for spray irrigation of crops, watering of green spaces and washing of roads"

ANSES undertakes independent and pluralistic scientific expert assessments.
ANSES's public health mission involves ensuring environmental, occupational and food safety as well as assessing the potential health risks they may entail.
It also contributes to the protection of the health and welfare of animals, the protection of plant health and the evaluation of the nutritional characteristics of food.
It provides the competent authorities with all necessary information concerning these risks as well as the requisite expertise and scientific and technical support for drafting legislative and statutory provisions and implementing risk management strategies (Article L.1313-1 of the French Public Health Code).
Its opinions are made public.
This opinion is a translation of the original French version. In the event of any discrepancy or ambiguity the French language text dated 30 March 2012 shall prevail.

On 7 August 2009, the French Agency for Environmental and Occupational Health Safety (AFSSET), which was merged into the French Agency for Food, Environmental and Occupational Health & Safety (ANSES)[1] as of 1 July 2010, received a formal request from the Director General for Health at the Ministry of Health and the Director for Water and Biodiversity at the Ministry of Ecology, to conduct an assessment of the health risks associated with spraying using treated wastewater (TWW).

1. BACKGROUND AND PURPOSE OF THE REQUEST

1.1. Background of the request

Reuse of treated wastewater (RTWW) for irrigating crops or watering green spaces has benefits with regard to preservation of water resources, especially in unfavourable climatic conditions (prolonged period of drought) or in areas where water resources are not readily available.

The conditions for RTWW must be governed by regulations in order to prevent the health risks associated with this practice. Indeed, even when treated by sewage treatment plants (*STations d'EPuration des eaux usées* - STEPs), urban wastewater contains various pathogenic microorganisms and potentially toxic organic and mineral elements.

To ensure the protection of public health and the environment, in July 1991, the Water Section of the French High Council for Public Health (CSHPF) defined the sanitary requirements and techniques applicable to facilities using wastewater, post-treatment, for the purpose of watering or irrigation. These requirements were updated in 2001 and a draft

[1] AFSSET and the French Food Safety Agency (AFSSA) merged to create the French Agency for Food, Environmental and Occupational Health & Safety (ANSES) on 1 July 2010.

Order was drawn up pursuant to Article 24 of the Decree of 3 June 1994 relating to the treatment of urban wastewater. This draft was sent to the French Food Safety Agency (AFSSA) for an opinion.

AFSSA issued an opinion[2] in 2008 on the health risks to humans and animals related to oral exposure. The use of TWW for watering green spaces and the hazards this practice may present for local residents or professionals (mainly from spraying) were excluded from AFSSA's report, which defined the constraints regarding use, distances and types of land according to the level of quality of the TWW.

In 2010, AFSSA supplemented its analysis with an assessment of the risks associated with effluents from plants processing Category 1, 2 or 3 animal by-products, still for the purposes of reuse to irrigate crops intended for human or animal consumption (AFSSA, 2010)[3].

The subject of this present Opinion is the assessment of the health risks to humans associated with exposure via the respiratory and/or mucocutaneous routes.

Article 4 of the Order of 2 August 2010[4], published in the Official Journal on 31 August 2010, only authorises reuse of TWW by spraying within the framework of a pilot project, following a favourable opinion from ANSES.

1.2. Subject of the request

The objectives of this work are therefore to:

- assess the health risks via the respiratory and mucocutaneous routes associated with RTWW for spray irrigation of crops and watering of green spaces;
- confirm or refute the criteria and values adopted by AFSSA in the context of such spraying;
- make recommendations to supplement the Order of 2 August 2010 and replace the experimental study laid down in its Article 4; these recommendations should include levels of treatment and propose ways of controlling the risk associated with spray irrigation;
- assess the health risks associated with RTWW for washing roads.

The expert appraisal conducted within the framework of this request does not take into account:

- the impact of RTWW on the environment, as this is governed by regulations;
- routes of indirect contamination via ingestion of plants watered with TWW (addressed by AFSSA in 2008) and via hand-to-mouth or hand-to-hand contact.

2. ORGANISATION OF THE EXPERT APPRAISAL

The expert appraisal was carried out in accordance with French Standard NF X 50-110 “Quality in Expert Appraisals – General Requirements of Competence for Expert Appraisals (May 2003)”.

[2] AFSSA (2008). Reuse of treated wastewater for watering or irrigation. 69 p.

[3] AFSSA (2010). Opinion of the French Food Safety Agency on the risk assessment of effluents from processing plants of Category 1, 2 and 3 animal by-products intended to be reused for the irrigation of food and feed crops 34 p.

[4] Official Journal of the French Republic. (2010). Decree of 2 August 2010 relating to the use of water resulting from the purification treatment of urban wastewater for irrigation of crops or green spaces - NOR: SASP1013629A .

This expert appraisal lies within the scope of the Expert Committee on Water (CES Water). ANSES entrusted the expert appraisal to the working group on "Reuse of treated wastewater". The methodological and scientific aspects of the work were presented to the CES between 4 October 2011 and 6 March 2012.

The scientific aspects of this Opinion are based on the final report of this collective expert appraisal, which was approved by the Expert Committee at its meeting of 7 February 2012.

3. ANALYSIS AND CONCLUSIONS OF THE CES

3.1. Irrigation of crops, watering of green spaces and golf courses

3.1.1. Assessment of the health risks associated with chemical contaminants

- **Description of the method**

The assessment of the health risks associated with chemical contaminants was conducted according to the following approach:

i. identification of chemical hazards;
ii. assessment of exposure;
iii. research and selection of toxicity reference values (TRVs) for the chemical contaminants selected;
iv. characterisation of the health risks.

Data on the concentrations of micropollutants in STEP effluents are, to date, partial and relatively recent.
The chemical characterisation of TWW drew on the results of two studies[5] that quantified different micropollutants in STEP discharges. In total, more than a hundred chemical contaminants output by STEPs were quantified.

There are potentially many criteria for selecting micropollutants of interest. In the context of this work, chemical contaminants were selected considering:

- the composition of the TWW: the substances selected as a priority were those quantified in the AMPERES[6] and/or RSDE1[7] studies;
- the volatility of the chemical contaminants: low volatility substances were selected, for which Henry's constant < 1 Pa.m^3/mol or the vapour pressure < 100 Pa if Henry's constant was not available;
- the substances' toxicity to humans: the substances selected were those on the list of carcinogenic, mutagenic, reprotoxic (CMR) substances that have been

[5] Research programme on the Analysis of Priority and Emerging Micropollutants in Discharges into Surface Waters (AMPERES).

Action on Research and Reduction of Substances that are Hazardous to the Aquatic Environment (RSDE1).

[6] Coquery M., Pomiès M., Martin-Ruel S., *et al.* (2011). Mesurer les micropolluants dans les eaux brutes et traitées - Protocoles et résultats pour l'analyse des concentrations et des flux. *Techniques-Sciences-Méthodes*; 1/2: 25-43.

Martin Ruel S., Choubert J.M., Esperanza M. *et al.* (2011). On-site evaluation of the removal of 100 micro-pollutants through advanced wastewater treatment processes for reuse applications. *Water Science and Technology*; 63 (11): 2486-2497.

[7] INERIS. Les substances dangereuses pour le milieu aquatique dans les rejets au milieu naturel. Bilan de l'action nationale de recherche et de réduction des rejets de substances dangereuses dans l'eau. Volet stations d'épuration [Substances hazardous to the aquatic environment in discharges into the natural environment. Assessment of the national action on research and reduction of discharges of hazardous substances into water. Sewage treatment plants component]. Action 11: ONEMA-INERIS Agreement 2008. Verneuil-en-Halatte: INERIS, 2009. 55 p. (Study report no. DRC-09-95687-02648A).

the subject of a harmonised European classification or those that have been the subject of a classification by the International Agency for Research on Cancer;

- The availability of a TRV[8] for the respiratory route or for mucocutaneous contact.

Ten chemical contaminants were thus selected: hexachlorocyclohexane, dieldrin, di(2-ethylhexyl)phthalate (DEHP), pentachlorophenol, chromium, nickel, cobalt, arsenic, cadmium and lead.
As the watering durations are different, irrigation of crops[9] and watering of golf courses and green spaces were addressed separately. "Worst case" scenarios[10] for chronic exposure were established for five categories of adult population:

- workers;
- bystanders;
- residents;
- users of green spaces;
- athletes.

Concerning the selection of TRVs, priority was given to the values established by ANSES. In the absence of TRVs developed by ANSES, a survey was conducted of existing TRVs and those developed by international bodies. This led to selection of values matching the exposure scenarios and, in the event that there were several TRVs for a given chemical contaminant, the value offering most protection to human health. Given the lack of TRVs for the mucocutaneous route, the risk assessment was conducted for the respiratory route only.

Lacking micropollutant concentrations representative of all TWW in mainland France, rather than calculate the health risk for each of the selected substances, it was deemed more appropriate to calculate the theoretical maximum concentrations in TWW not to be exceeded, for each category of population and for a hazard quotient equal to 1 when the substance has an effect threshold and a risk of 10^{-5} when the substance has no effect threshold. For each substance, the theoretical maximum concentration not to be exceeded was then compared to the average concentration found in TWW in the AMPERES and RSDE1 studies, to which was added a safety factor equal to twice the standard deviation (95^{th} percentile).

■ Results

The theoretical maximum concentrations not to be exceeded in TWW to avoid the occurrence of an adverse effect on health for the populations exposed by the respiratory route, based on maximum assumptions, are far higher (between 10^2 and 10^7 times) than the concentrations found in the TWW studied during the AMPERES and RSDE1 programmes. In the light of these results, apart from point or accidental pollution, these substances should not be found in TWW at concentrations that could induce an adverse effect on the health of populations, via the respiratory route, during spray irrigation of crops or watering of green spaces and golf courses.

[8] Threshold TRV or non-threshold TRV corresponding to an excess risk per unit (ERU).

[9] Only maize was selected in view of its water needs and the irrigation time necessary, which would correspond to a "worst case" exposure situation for an individual.

[10] RTWW takes place over four months between April and October depending on the crops and regions; irrigation always takes place at the same time of day and the populations selected are exposed to each irrigation operation.

3.1.2. Assessment of the health risks associated with microorganisms

■ **Description of the method**

The quantitative assessment of a health risk associated with a microorganism requires, for an identified hazard, data relating to the occurrence, the concentration and the dose-response relationship for the exposure routes considered.
In the framework of this expert appraisal, the feasibility of a risk analysis was explored.
This concluded that an analysis of the microbiological risks was impossible because of:

- the lack of exposure data;
- the existence of a single dose-response relationship for *Legionella pneumophila* for the respiratory route that cannot be transposed to other microorganisms;
- complex survival conditions for microorganisms in the environment;
- the absence of an acceptable threshold value to characterise the risk.

Thus, only the hazards and their potential effects on human health were identified.
The microbiological hazards were identified on the basis of a review of the literature relating to contamination of TWW (taking into account contamination of raw sewage and the effect of treatments on the reduction in the concentrations of microorganisms) supplemented by a search of epidemiological data on RTWW for spraying.
A list of hazards was drawn up, for which only biological agents that are pathogenic via the respiratory and mucocutaneous routes were selected.

■ **Results**

The microbiological composition of TWW varies greatly depending on the season, the origin of the wastewater collected, the health status of the populations, the treatment applied in the STEP, etc. Accordingly, it contains a wide variety of microorganisms, in varying concentrations, that are potentially pathogenic to humans (bacteria, fungi and their toxins, viruses and protozoa) and may induce health effects via the respiratory and/or mucocutaneous routes depending on the sensitivity of the exposed person and the dose of microorganisms to which they are exposed.
The epidemiological data found in the literature are, for their part, insufficient to be able to conclude as to whether there is a health risk associated with the presence of microorganisms in TWW for RTWW, since few data on the microbiological composition of reused TWW are available.

3.2. Conclusions and recommendations of the collective expert appraisal for the irrigation of crops, and the watering of green spaces and golf courses

In the current state of knowledge, it is not possible to conclude as to the total absence of chemical and microbiological risks via the respiratory and/or mucocutaneous routes associated with RTWW for spraying. The CES therefore recommends limiting as far as possible human exposure to TWW during spraying operations.

It proposes a series of measures to limit this exposure, concerning:

- water quality;
- supervision of practices;
- limiting human exposure.

These recommendations supplement the Order of 2 August 2010 and clarify the regulatory framework for the spray irrigation of crops, and watering of golf courses and green spaces. They are intended to be a substitute for the experimental study recommended in Article 4 and defined in Annex III of this same Order. For this reason, applications for RTWW by spraying should be examined by the prefectural services of the *département* where the RTWW takes place, in the same way as any type of RTWW application.

3.2.1. Water quality

With regard to the quality of TWW reused, the CES recommends compliance with the Order of 2 August 2010 concerning:

- the water quality defined in Annex I for the uses as defined in Annex II of the same Order;
- the TWW monitoring programme defined in Article 10.

Concerning storage, as mentioned in Article 3 of the Order of 2 August 2010, the storage conditions of the TWW should not promote the development of pathogenic vectors or agents.
Water should not be stored for irrigation in the event of temporary degraded operation of the STEP.

3.2.2. Supervision of practices

- **Related to the design and management of the distribution network**

The TWW distribution network must be designed in such a way that it does not degrade the quality of the water. Everything must be implemented to avoid the possible proliferation of microbial species, in particular by prohibiting dead legs.
The network should be designed in such a way that purges can easily be carried out by the operator.
The irrigation network should be drained completely and flushed under pressure at the end of the irrigation season and at the time it is started up. Procedures for cleaning and maintaining this network, determined by the operators, should be developed and implemented.

- **Related to the sprinklers and spray irrigation systems**

The use of low-pressure sprinklers should be preferred in windy areas: pressure below 3.5 bar for turbines or sprinklers offering full coverage and less than 5.5 bar for water guns. Furthermore the use of sprinklers with a low apogee should also be favoured.

The Order of 2 August 2010 advocates safety distances defined to protect sensitive activities but not seeking to limit human exposure.
In order to limit the exposure of populations beyond the theoretical reach of the sprinkler, the CES recommends:

- the establishment of safety distances modulated according to the type of sprinkler used, corresponding to at least twice the reach of the sprinkler, to be complied with regardless of the wind speed;
- the installation of physical barriers (hedges, walls, etc.) around the irrigated sites.

In addition to the information requested in Article 9 of the Order of 2 August 2010, before the start of the irrigation campaign, the operator should provide the competent authorities with a description of the model of the sprinklers, their operating pressure, details of the irrigated land and its gradient, the distance of this land from homes and roads, the volume of water in the storage tank where applicable, and the periods of irrigation.
In accordance with Article 12 of the Order, the operator should record the details of its irrigation programme, including the above points, in a register and make it available to the competent authorities.

3.2.3. Limiting exposure

- **Residents - Bystanders**

Prohibiting the presence of the public at the time of spraying would considerably reduce exposure.

Therefore, watering at night-time could be prioritised for green spaces, as this period is characterised by lower evaporation and therefore more limited dispersion. This measure would also therefore help limit exposure of the general public at the time of watering, although daytime is more favourable to microbial reduction (Teltsch *et al.*, 1980[11]; Karra and Katsivela, 2007[12]).
The CES, by reference to the recommendations for Australia[13], recommends that green spaces watered with TWW be closed to users for 1 to 4 hours following watering. Signs at the entrances of green spaces open to the public and golf courses should be erected to inform users of the use of TWW and remind them of good hygiene rules to avoid exposure to potential contaminants found in the TWW via hand-mouth contact, rubbing of eyes after touching areas watered by the TWW, etc.

- **Professionals**

Professionals should not be present on the irrigated sites at the time of spraying.
Collective, personal and medical protective measures should be defined, such as those proposed in the report.
With regard to medical prevention, the CES recommends that medical information be collected and processed at regional level (occupational disease consultation, Regional Health Agency (ARS), Interregional Epidemiology Unit (CIRE), etc.) in order to document any potential health effects from this exposure and advance knowledge of the risks.

3.2.4. Acquisition of knowledge

Given the gaps identified and/or the still only fragmentary data available that prevented it from completing an assessment of the health risks associated with RTWW by spraying, the CES recommends that studies and/or research work be undertaken with the aim of:

- quantitatively characterising the microbiological and chemical composition of TWW and in particular, at pilot sites, screening for the microorganisms listed in Annex III of the Order of 2 August 2010 to determine the effectiveness of the treatment facilities in this respect (especially for amoebas and *Legionella*) and the level of contamination of TWW by these same microorganisms;
- conducting epidemiological studies in the vicinity of sites (golf courses, green spaces in particular) where RTWW by spraying is practised;
- conducting campaigns to measure aerosols around the sprayed areas in order to characterise them from a chemical and microbiological point of view and especially continuing the experimental study to assess the risk of dispersion of biological aerosols by spraying of TWW for crop irrigation in order to estimate the dispersion of particles beyond its reach, refine the safety distances and assess the effect of any screens;
- producing data on the dose-response relationships of the microorganisms found in the TWW for exposure via the respiratory and/or mucocutaneous routes;
- producing toxicological data on the chemical contaminants found in the TWW for exposure via the respiratory and/or mucocutaneous routes;
- assessing the effects of interactions between the different chemical compounds found in the TWW.

[11] Teltsch B., Kedmi S., Bonnet L. *et al.* (1980). Isolation and identification of pathogenic microorganisms at wastewater-irrigated fields: ratios in air and wastewater. *Applied and environmental microbiology*; 39 (6): 1183-1190.
[12] Karra S. and Katsivela E. (2007). Microorganisms in bioaerosol emissions from wastewater treatment plants during summer at a Mediterranean site. *Water Research*; 41: 1355-1365.
[13] Australian EPA (2006). Australian guidelines for water recycling: managing health and environmental risks (phase 1). Canberra, Nov 2006. 389 p.

In addition the CES recommends the creation of a database containing all of the results of health inspections of sites practising RTWW (water quality, safety distances, diseases recorded) in order to benefit from the lessons learned about these practices.

3.3. Washing of roads

In the absence of any exposure data, especially on the characteristics of the water particles emitted by the vehicles used to clean public spaces, or data on the exposure scenarios for workers and bystanders (the only population categories identified as potentially exposed), it was not possible to conduct a health risk assessment for these two categories of population.

However, considering that workers, especially water-jet operators, could be particularly exposed to particles of TWW, and with a view to being able to conduct a health risk assessment, the CES recommends conducting a study to characterise their exposure according to the equipment used.

As with irrigation, other water resources whose quality is generally not controlled or only partially controlled are used for washing roads. The CES therefore recommends the creation of a database to record and compile information on the quality of water used.

4. AGENCY CONCLUSIONS AND RECOMMENDATIONS

The French Agency for Food, Environmental and Occupational Health & Safety adopts the conclusion and recommendations of the Expert Committee on Water.

In addition, it restates the recommendation made by the Agency in its report entitled "Reuse of treated wastewater for watering or irrigation" (2008), relating to the monitoring of metal trace elements[14] in TWW during the six months of study to validate the treatment process for the constitution of the dossier for the application for authorisation.

The Director General

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[14] Cadmium, chromium, copper, lead, mercury, nickel and zinc.

KEYWORDS

Reuse of treated wastewater, irrigation, spraying, aerosols, microbiology, micropollutants, health effects.