Supply security for critical chemicals needed for water supply and sanitation during COVID-19-Crisis

A Preliminary Assessment

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1. STEERING BRIEF

1.1 Scene setter

The COVID-19 crisis may lead to disruptive supply chains for critical materials needed for water supply and sanitation. It was claimed by stakeholders that in particular the supply of flocculation agents could be jeopardised in the very near future, thus leading to critical infrastructure failure with potentially high damage to man and environment. Attention was drawn to the fact that apparently only 3 manufactures of critical raw materials, cover 95% of the European market share (NB: this information could not be verified).

The JRC was asked to do a preliminary assessment of the situation, also in view of possible alternative to current (petrol) based polymers used in the water supply and sanitation.

1.2 Objectives

- Review the principal needs for flocculation and coagulation agents in water supply and sanitation
- Analyse the European market for the respective products
- Conduct a preliminary risk assessment of major threats caused by COVID-19
- Investigate possible alternative substrates

1.3 Results and Observations

- **This is a preliminary assessment conducted under home office conditions.**
- **The market of end material suppliers is vast and offers some resistance from the production side - road-based transportation is clearly identified as a vulnerability.**
- **Wastewater treatment failure would have primarily an impact on the environment, whereas drinking water supply failure would be catastrophic.**
- **Smaller water supply plants as well as areas relying on surface water as raw water source are likely to be most vulnerable.**
- **The market of end material suppliers is vast and offers some resilience, also due to stock keeping of key materials (1-3 weeks).**
- **Local differences may exist. A vulnerability mapping with regard to raw water sources used for drinking water productions was not possible, but should be conducted.**
- **SARS-CoV-2 risks related to wastewater sanitation and water reuse are under control.**
- **An unlimited transportation permission including across European borders should be enabled to secure a smooth supply to drinking water or wastewater facilities.**
- **In conclusion: Green-chemistry based alternatives exist, but a short-term substitution of traditional flocculants/coagulants is unrealistic.**

2. BACKGROUND INFORMATION

2. 1 Flocculation and coagulation

Flocculation is commonly confused with coagulation, and the terms are consequently used to some extent interchangeably, but they are very different processes.
Coagulation and flocculation are an essential part of drinking water treatment as well as wastewater treatment.
Flocculation is a physical process in which the fine solids produced by coagulation are brought together into larger particles using controlled low levels of shear. This facilitates their removal from the water phase.

2.2 Flocculation in drinking water supply

In drinking water treatment, flocculation is done to remove any sort of particulate matter from the raw water entering the potabilisation process. It is usually performed using shear, but flocculants play a major role, in particular when surface water is used for potabilization. Among the constituents of raw water, which are effectively removed by these processes, are:

- Pathogens (Viruses, bacteria and protozoa): Adequately designed and operated water treatment plants remove already more than 99.5 % of the pathogens prior to the subsequent disinfection step
- Natural organic matter jeopardizing potability
- Inorganics including toxic elements such as arsenic and heavy metals or critical constituents such as fluorides or phosphates

The removed particulate matter results into a sludge produced from the treatment of raw water and has its origin in different steps of the potabilization process such as:

- the extractions or blowdowns undertaken during sedimentation (or flotation)
- filter backwashing as well as, if applicable,
- clarification membrane backwashing.

The suspended solids contained in this sludge include:

- matter present in the water prior to treatment: plankton, flocculated organic and mineral matter, metal hydroxides from the oxidation of ions present in the raw water (iron, manganese);
- hydroxides from coagulation-flocculation reagents added as part of the treatment process;
- if applicable, adsorbent reagents (powdered activated carbon - PAC), as well as debris detached from granulated active carbon (GAC) filter biological films;
- In the case of carbonate removal using lime, these solids will mainly consist of calcium carbonate.

In order to facilitate the waste management, dewatering is a primary issue and also here flocculation/coagulation agents are essential to reduce the volumes of waste to be handled.

2.3 Flocculation in wastewater sanitation

Chemical flocculants are used to promote flocculation in wastewater treatment. The addition of coagulant chemicals to primary clarifiers, or to other dedicated physical separation processes, is an effective way of reducing the load to downstream biological processes or, in some cases, for direct discharge. This practice is generally referred to as chemically enhanced primary treatment, or CEPT.

Principal disadvantages of CEPT is the production of highly putrescible sludges (sewage sludge) and the high operating costs of chemical addition. However, advantages outweigh the drawbacks in particular with regard to:

- treatment under emergency measures;
- avoidance of excess wastewater discharges during storm events;
- primary treatment before biological treatment, where the above disadvantages become of lesser impact.

Due to the hazardous character of sewage sludge, de-watering is FUNDAMENTAL for the subsequent sludge management, entailing often (co)incineration processes, requiring a solid content of 20% or better.

2.4 Critical raw materials

The commonly used metal coagulants fall into two general categories: those based on aluminium and those based on iron.

Aluminium coagulants include:

- aluminium sulphate
- aluminium chloride
- sodium aluminate
- aluminum chlorohydrate
- polyaluminum chloride
- polyaluminum sulfate chloride
- polyaluminum silicate chloride
- forms of polyaluminum chloride with organic polymers
- polymerized aluminum-iron blends

The iron coagulants include:

- ferric sulphate
- ferrous sulphate
- ferric chloride
- ferric chloride sulphate
- polyferric sulfate
- ferric salts with polymers.
- polymerized aluminum-iron blends

Other chemicals used as coagulants include:

- hydrated lime
- magnesium carbonate.

Organic polymers, such as polyacrylamides are essential, too. Cationic polyacrylamides are used for dewatering purposes, whereas anionic and neutral polyacrylamides are used for the flocculation process.

2.5. Market overview for chemicals used in water treatment

It is projected that the global market for water treatment chemicals will achieve 56.57 billion USD by 2025 and growth of a Compound Annual Growth Rate (CAGR) of 4 to 6 %.
The market is separated into coagulants, flocculants, corrosion inhibitors, scale inhibitors, biocides and disinfectants and, from an end-user side, in energy/power production, municipal supply and sanitation, oil & gas industries, mining. Technological innovation is observed in close conjunction with strict public regulations on environmental safety and precaution, the latter also pushing for an increased demand for eco-friendly (green) chemicals. The market is primarily dominated by the Energy Sector having special requirements for water treatment for cooling water (!). The market in Germany is in expansion with an expected 4% growth per year, placing it at the first position. UK, France, Spain, Italy are next followed by the rest of Europe and Russia.
Among the European countries hence, Germany accounts for the major market share currently and is expected to continue its dominance. The consistently growing demand for electricity is likely to boost the consumption of water treatment chemicals by the power generation industry. Shifting focus towards green chemicals is likely to offer a major growth opportunity for the market studied in the coming years, which is an interesting aspect.

Major players identified in the European Market include:

- Solenis LLC
- Ecolab Inc.
- Kemira Oyi
- Kurita Water Industries Ltd.
- Suez S.A.
- Dow Chemical Company
- Cortec Corporation
- Buckman Laboratories International Inc.
- Akzos N.V. Solvay S.A.,

2.6. Risks and impacts caused by COVID-19 Crisis

What follows is a preliminary risk assessment based on interviews and exchanges with experts employed in the sector as well as an internet research. Possible threats and hazards are assessed in terms of likelihood (improbable, low, possible, likely), impact (low, medium, high) and resulting risk (low, moderate, high) Although not representative, the analyses indicate need for some priority actions.

- ***Failure of Wastewater Treatment Plants***
    - *due to staff shortage*: COVID-19 infection rate is raising in EU Member States, but still not a level impacting work force. As critical infrastructure, installations have emergency procedures in place. In smaller plants, skilled working forces may not be easily replaced.
      Likelihood: low (at present)
      Impact: medium
      Risk: low

- *power failure*: Wastewater Treatment Plants rely on continuous power supply. Disruptive energy supply is a major risk but, as critical infrastructure, emergency plans and back-ups are in place
  Likelihood: improbable
  Impact: high
  Risk: moderate (mitigation measures are in place)

- *critical end materials*: Critical end materials/chemicals include, in addition to the aforementioned agents for flocculation/coagulation, a series of products used in the operation of the plant and its maintenance. The treatment plants have optimised stocks and consequently delivery-on-time is a common principle. Nonetheless, as critical infrastructure, they keep stocks ensuring a business continuity typically for 1-3 weeks. While cross-border transportation is an issue due to quarantining, increased border controls and increased demand of drivers, the market for end material producers is sufficiently diverse to offer resilience. Local supply disruptions are likely with increased frequency, the longer the transport restrictions last.
  Likelihood: possible
  Impact: high
  Risk: high (mitigation measures are in place, but have a limited duration due to decreased stock keeping. Smaller WWTP are more vulnerable)

- *critical raw materials*: These materials are at the start of the supply chain and delivered to end material manufactures. Due to their low cost, large scale factories are favoured. While business continuity plans ensure a continuous production for longer periods, transportation to end manufactures due to the aforementioned gains bigger importance. The claim that 3 suppliers cover 95% of the manufacture end users cannot be verified, but is probable. Alternative oversees transportation is jeopardized.
  Likelihood: likely
  Impact: high
  Risk: high (Immediate action needed)

- ***Failure of Drinking Water Supply Plant***
  - *due to staff shortage*: COVID-19 infection rate is raising in EU Member States, but still not a level impacting work force. As critical infrastructure, installations have emergency procedures in place. In smaller plants, skilled working forces may not easily be replaced. In the drinking water sector, very small supplies exist in significant numbers, but can be compensated, in case of failure, with civil protection mechanisms in place. Failure probability increases with infection rates.
    Likelihood: low (at present)
    Impact: high
    Risk: moderate

  - *power failure*: Drinking Water Treatment Plants rely on continuous power supply. Disruptive energy supply is a major risk, but as critical infrastructure, emergency plans and back-ups are in place.

Likelihood: **improbable**
Impact: **high**
Risk: **moderate (mitigation measures are in place)**

- *critical end materials*: Although less chemicals are used, also here critical end materials/chemicals include, in addition to the aforementioned agents for flocculation/coagulation, a series of products used in the operation of the plant and its maintenance. The treatment plants have optimised stocks and consequently delivery-on-time is a common principle. Nonetheless, as critical infrastructure they keep stocks ensuring a business continuity typically for 1-3 weeks. While cross-border transportation is an issue due to quarantining, increased border controls and increased demand of drivers, the market for end material producers is sufficiently diverse to offer resilience. Local supply disruptions are likely with increased frequency, the longer the transport restrictions last.
  Likelihood: **possible**
  Impact: **high**
  Risk: **high with a potential to escalate to catastrophic (mitigation measures are in place, but need to be reinforced)**

- *critical raw materials*: Situation parallel to the wastewater treatment but impact is primarily of health relevance. Due to their low cost, large scale factories are favoured. While business continuity plans ensure a continuous production for longer periods, transportation to end manufactures due to the aforementioned gains bigger importance. The claim that 3 suppliers cover 95% of the manufacture end users cannot be verified, but is probable. Alternative overseas transportation is jeopardized.
  Likelihood: **likely**
  Impact: **high**
  Risk: **high with a potential to escalate to catastrophic (immediate action needed)**

- Unknowns. Although indications exist that wastewater can act as vector for corona-viruses, the overall risk of transmission is very low for wastewater and only theoretical in case of drinking water supply. Risks related to aerosolization, e.g. use of treated wastewater in irrigation are under control.

2.7. Mitigation measures

Mitigation measures should primarily aim at an uninterrupted supply with key raw materials transportation to European manufacturing sites as well as the subsequent distribution network.

To secure a smooth supply to drinking water or wastewater facilities an unlimited transportation permission including across European borders, is required.

Although protection of the active labour force is paramount, a prioritized conduction of Corona-testing for the manufacturing personnel cannot be justified.

Likewise, the protective equipment and hygienic requirements needed in the sector OUTSIDE the crisis, should be sufficient to ensure protection of the work force DURING the crisis.

In case of supply shortage, chemicals on stock can be used to improvise disinfection measures. A WHO protocol for this exists and can be prepared in the plants.

The source of raw water used for potabilization influences greatly the need for flocculation/coagulation agents as well as other chemicals. Based on information accessible at the moment of drafting this paper, NO mapping can be performed. This would be necessary for a local vulnerability analysis and should be envisaged.

Natural flocculants, due to their eco-friendliness, have gained increasing attention for (waste) water treatment and are promising alternatives to oil-based synthetic flocculants. Such flocculants include microbial extracellular polymeric substances (EPS), chitosan, polysaccharides and others. However, large-scale production capacities are insufficient and hampered by the same transportation limitations.

2.8. SARS-CoV-2 and water supply/sanitation

Persistence of severe acute respiratory syndrome-associated coronavirus (SARS-CoV) was observed in feces, urine and water. Lab tests indicated a survival of coronaviruses up-to 10 days in tap water and 100 days in wastewater. Coronaviruses can remain infectious for long periods in water and pasteurized settled sewage, suggesting contaminated water is a potential vehicle for human exposure if aerosols are generated.

Likewise, certain types of coronavirus were recovered from lettuce with an efficiency of 19.6% yet could not be recovered from strawberries. PCR-based identification suggests that viral metagenomes were a conservative estimate of the true viral occurrence and diversity, but confirmed the aforementioned findings.

Considering these findings, WHO summarized the information on WaSH and CoV/SARS CoV2. Although persistence in drinking-water is possible, there is no evidence from surrogate human coronaviruses that they are present in surface or groundwater sources or transmitted through contaminated drinking water. It is not certain how long the virus that causes COVID-19 survives on surfaces, but it seems likely to behave like other coronaviruses.

Furthermore, although being detected, there is no evidence that the COVID-19 virus has been transmitted via sewerage systems with or without wastewater treatment. Further, there is no evidence that sewage or wastewater treatment workers contracted the severe acute respiratory syndrome (SARS), which is caused by another type of coronavirus that caused a large outbreak of acute respiratory illness in 2003.

If wastewater is used for irrigation through sprinkling, micro-spraying or similar techniques and no proper disinfection is applied aerosols may form a possible vector. In Europe, such applications are banned and the recently proposed risk management framework from JRC (Sanz and Gawlik, 2014, 2017) for the reuse of treated waster, also embedded also in the Proposal of the Water Reuse Regulation, offers sufficient protection with regard to water reuse schemes in agricultural irrigation.

3. WEB SOURCES USED

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