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"Separate Collection of Iodinated X-ray Contrast Media in Hospitals"

Phase 2: Implementation

Final Report
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Research Project in Co-operation with

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Maria Heimsuchung
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1 Introduction

Iodinated X-ray contrast medial (RKM) are used for the radiological imaging of the body's soft parts. They are administered to patients in high dosages ranging from 3 to 100 g of iodine, in exceptional cases also up to 300 g of iodine per patient and examination [1]. During the test phase of the project "Separate Collection of Iodinated X-ray Contrast Media in Hospitals", an average dosage of 27 g of iodine per patient and examination in the form of X-ray contrast media has been administered. Iodinated X-ray contrast media pass through the body unmetabolised and are almost completely excreted into the urine after 24 hours [2, 3, 4]. The excretion half-time is two hours [2, 4]. These substances being very polar and inert, they are difficult to eliminate in wastewater treatment plants. The examinations of a Berlin WWTP have revealed that the elimination rate of iodinated X-ray contrast media, measured as AOI (adsorbable organic iodine) is below 8% [5]. Iodinated X-ray contrast media are often persistent to biodegradation. A first degradation step however, may cause a separation in side chains producing stable metabolites instead of initiating a deiodation process [6]. As it has been reported already, the biological treatment step of the large-scale WWTP Köln-Stammheim achieves an elimination rate for iopromide and iomeprol up to 90% [7]. The elimination rate of iopamidol and amidotrizoic acid is however, clearly lower. It is not known, whether also the metabolites of iodinated x-ray contrast media have been analysed in the scope of the mentioned examinations. Iodinated X-ray contrast media are detectable in the hydrological cycle: in the Berlin surface waters the average AOI concentrations amount to 2 – 15 µg/L [8]. Previous studies have demonstrated that AOX concentrations (adsorbable organic halides) in hospital wastewaters are almost exclusively due to iodinated X-ray contrast media [6, 9].

In terms of clinical diagnostics, iodinated X-ray contrast media occupy a central position and cannot be substituted at present. In general, these substances are well tolerated in humans, but undesirable side effects such as kidney impairment have occurred [10]. According to the current state of knowledge, they have no eco-toxicological effects [1, 11, 12]. Controversy exists however, about the ecological toxicity of these persistent substances. In addition, no consolidated findings are available concerning the properties of the metabolites of iodinated X-ray contrast media [13]. Data referring to their structure, properties and toxicity are documented in detail in the report on the project's feasibility study [14].

The estimated annual consumption of iodinated X-ray contrast media in Germany is about 360 – 500 t [8, 15]. Approximately half of their molecular mass consists of iodine molecules [16]. The main sources of emission are hospitals and medical offices at equal shares [9, 13]. Considering the principles of a preventive strategy for environmental protection and the imperative to minimise water impurities stipulated in the German Drinking Water Directive, iodinated X-ray contrast media should not be discharged into the water cycle. Since iodinated X-ray contrast media are excreted almost completely, unmetabolised and locally concentrated in the patient's urine, the obvious choice is to collect them at their origin and thus to prevent their emission into the water circulation.

The R&D project "Separate Collection of Iodinated X-ray Contrast Media in Hospitals" has been carried out in two phases: phase 1, the feasibility study, conducted from 1 April 2004 to

30 April 2005, has provided the basis for the second project phase implemented from 1 May to 31 December 2005. During the second phase, the decentralised collection concept featuring mobile urine containers was tested in order to retain the iodinated X-ray contrast media at the source. The two week analysis of the wastewater of the Caritas-Klinik Pankow in February 2006 following the actual project phase, served the purpose to furnish proof of whether the urine collection measures would lead to a decrease in the iodine load of the wastewater on site.

In the scope of the feasibility study, three collection concepts have been developed and systematically evaluated according to the following criteria: integration into the existing sanitary technology and waiting rooms, additional medical care, integration into the medical treatment procedures of the radiology department and the wards respectively, quality of patients' treatment, quantity and degree of collection. On the basis of the results which are summarised in an article published in GWF [17], the most workable collection concept has been selected for implementation at one ward in two Berlin hospitals. The nursing staff collected the urine of patients to whom iodinated X-ray contrast media had been administered, in mobile urine containers. In a weekly rhythm, composite samples were produced to determine the AOI and AOX concentrations. Afterwards, the urine which was not required for analyses, was disposed of through three different disposal paths: residual waste disposal, hazardous waste disposal and supply to research institutions conducting tests on iodine separation.

The R&D project was coordinated by Kompetenzzentrum Wasser Berlin gGmbH and Berliner Wasserbetriebe, in cooperation with the GÖK Consulting AG and two Berlin hospitals, the Charité Campus Virchow-Klinikum and the Maria Heimsuchung Caritas-Klinik Pankow. The hospitals involved are excellent examples for hospital management in Germany, one offering the maximum, the other a primary level of health care. All project partners jointly contributed to the feasibility study and its implementation during the second project phase. Veolia Waser and Berliner Wasserbetriebe provided financial support.

10 Summary

Following the preparation of a feasibility study [14, 17], the KWB project „Separate Collection of Iodinated X-ray Contrast Media in Hospitals“ was implemented in two Berlin hospitals during a twenty week period of investigation. Since iodinated X-ray contrast media are detectable in the hydrological cycle, the project's objective is to develop suitable methods to reduce the load. This objective complies with the preventive strategy for environmental protection and the imperative to minimise water impurities stipulated in the German Drinking Water Directive.

The iodinated X-ray contrast media are excreted almost completely and unmetabolised into the patients' urine within 24 hours. It is therefore obvious to collect these substances at their origin. The urine was collected by means of mobile containers at one ward of a university hospital and at another of a hospital providing primary health care. The concerned in-patients were informed mainly by physicians and the nursing staff. The patients participated in the implementation of the test and demonstration phase on a voluntary basis. With regard to hygiene, all persons involved evaluated the mobile urine containers as being practicable and ideal, in no case they were considered to be inapplicable. The collected urine was not disposed of via the usual wastewater path but, after the addition of a gel for hardening purposes, as residual waste and as hazardous waste. Moreover, the urine was made available to research institutions carrying out examinations referring to iodine degradation and iodine recovery.

In the university hospital Charité CVK, 59% of the patients concerned participated in the urine collection procedure, in the Maria Heimsuchung Caritas-Klinik Pankow, the hospital providing primary health care, the number amounted to 60%. The collection degree in reference to the iodinated X-ray contrast media administered at ward n^{o} 61 of Charité CVK, averaged out to 58%, and to 42% at ward n^{o} 6 of the Caritas-Klinik Pankow. In a weekly rhythm, the AOI and AOX concentrations of the collected urine were determined. The AOX concentrations were almost exclusively due to organic iodine compounds originating from X-ray contrast media. The average values for AOI concentrations measured in the patients' urine, amounted to 18 g/L. As a result of the urine collection in this five month test phase, approx. 5.2 kg of organic iodine could have been kept away from the wastewater.

The collection of urine in mobile containers belongs to the normal course of hospital workflow and could be extended to other patients. It should then be paid attention to the fact that all persons involved are well informed and that the input in terms of documentation is kept low. The patients having received X-ray contrast media should be identifiable however, by means of an accompanying explanatory slip for instance. For the physicians, the additional time expenditure amounted to approx. 5 minutes per patient, for the ward staff to 13 minutes for mobile patients and 15 minutes for non-mobile patients on the day of examination, and for the radiology staff it averaged out to 38 minutes per week.

The separate urine collection method has received a high acceptance rate among both hospital staff and patients. The majority of the interviewed physicians in both hospitals supported the project, 87% of the nursing staff stated a good/full acceptance rate. 97% of the

interviewed patients indicated a good/complete acceptance level, and 89% stated the environmental relief as their basic motivation for acceptance.

During the test and demonstration phase, three wastewater analyses of the Caritas-Klinik Pankow were conducted within a period of two to three weeks. The average AOX concentrations of the measurement campaigns ranged from 0.58 to 0.69 mg Cl/L, the average AOI concentrations varied from 0.43 to 0.51 mg Cl/L. These values confirm that organic iodine originating from X-ray contrast media found in hospital wastewater represents a major share of the AOX. The average iodine load of the wastewater within the three periods of investigation when the urine of patients having received X-tray contrast media had been collected at one ward, amounted to 82 g/d. During this time, 95 g/d of organic iodine in the form of X-ray contrast media was administered in the entire hospital. After the termination of the urine collection at one ward of the hospital, a two week measurement campaign was carried out with the objective of demonstrating a reduction of the organic iodine load and the AOI concentrations in the wastewater. This measurement campaign yielded an average AOX value of 0.60 mg Cl/L, an average AOI concentration of 0.51 mg Cl/L and an average organic iodine load of the wastewater with 100 g/d. The average administration amounted to 137 g/d of organic iodine in the form of X-ray contrast media. The comparison of the iodine loads indicates a tendency towards a reduction of the wastewater entries as a result of to urine collection.

The overall costs for a future urine collection in hospitals consisting of the expenditures related to material, residual waste disposal and personnel, can roughly be estimated to 10 €/patient, 7 €/L urine and approx. 380 €/kg iodine. To 80%, the main share of these costs results from staff expenses.

Starting from an average collection degree of 50% of the iodine quantity administered in the form of X-ray contrast media which was achieved in the scope of this project, the implementation of the decentralised collection concept would lead to a reduction of approx. 25% of the iodine quantity administered in all hospitals in Germany, since the total consumption of iodinated X-ray contrast media is administered in equal shares in hospitals and medical offices.

This project has clearly demonstrated that the separate collection of patients' urine by means of simple and decentralised methods, i.e. urine containers is a perfectly workable and hygienic practice for hospitals.