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Hydrology and Earth System Sciences Discussions

Interactive comment on "Modelling microbiological water quality in the Seine river drainage network: past, present and future situations" *by* P. Servais et al.

P. Servais et al.

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Authors reply to reviewers comments

Answers to the comments of reviewer 1:

Specific comments.

1. One of the "official" statements accepted and assumed in this paper is that: i) faecal coliforms are present in the faeces of humans and warm-blood animals and ii) faecal coliforms do not grow in natural waters although they persist if not eliminated biologically or via water treatment. Considering that i) the high organic matter concentration of the Seine river, in most cases of faecal origin and therefore contain the nutrients that

faecal coliforms uptake; ii) the large temperature interval for growing of faecal bacteria (12-48 °C); iii) the high concentration of faecal bacteria at the source points and iv) the existence of some reports indicating the growth of fecal bacteria in free waters, my questions are the following: (a) In what circumstances faecal bacteria may growth in Seine waters? (b) In case of growth, how this situation may change the output of the model? (c) If so which ones would be the consequences of the predictions?

Of course, if significant growth of FC would occur in the rivers, this will considerably modified the data of the model calculations. For example, after an important release of wastewater in a river, there would be competition between the growth and the mortality processes. The authors conducted during the scope of the study on faecal bacteria in the Seine network, a lot of batch experiments in which the fate of FC in river water was followed. The usual procedure of these experiments consisted in addition of FC (from a pure strain culture or from wastewater) to river water, incubation for several days during which the abundance of culturable FC was followed. In all cases a net decrease of the abundance of FC was always observed, even when we minimized the mortality process by adding FC to sterilised Seine river water (no grazing) and incubated in the dark (no impact of sunlight). So, we were never able to detect a growth of FC in the conditions met in the studied rivers. Most of the papers reporting possible growth of FC in river waters are from tropical areas with temperature significantly higher than those met in the rivers of the Seine network and with an important proportion of non-E. coli FC. In the Seine river network, we showed that E. coli represent around 80 % on average of FC (Garcia-Armisen et al., Canadian Journal of Microbiology, 2007, 53, 798-801). All the other models available in the literature describing the fate of FC in temperate rivers do not take a possible growth of FC in rivers. A sentence on the fact that possible growth of Fc was not taken into account in the model was added in the paragraph presenting the model: "In agreement with the results of batch experiments conducted by adding FC to sterile Seine river water, we neglect in the model the possibility of any significant growth of faecal bacteria in river waters."

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2. In section Introduction, paragraph 15, the DNA based tools to detect bacteria are mentioned as an alternative method to assess microbial risks in free waters. I want to express my strong concern on these tools since they only provide information on the presence of a nucleic acid sequence and do not provide any information at all about the capacity to infect or provoke a disease or just to know if the detected sequence is or not inside an alive cell.

The authors perfectly agree with reviewer on the fact that the DNA based tools to detect bacteria, that are mentioned as an alternative method to assess microbial risks in waters in the ms, only provide information on the presence of a nucleic acid sequence and do not provide any information about the capacity to infect or provoke a disease or just to know if the detected sequence is or not inside an alive cell. The following sentence was added in the revised text: “this type of methods only provides information on the presence of a nucleic acid sequence and not on the viability of the pathogens”.

3. Considering that a precise public health risk may be estimated from the epidemiological data that regularly are published in the area, what possibilities exists to incorporated and cross-validated the model and the output of the model with the current epidemiological of the region?

Presently as there is quite no bathing activity in the rivers of the Seine drainage network (it is clearly forbidden in most places), it is really unfeasible to make a link between the microbiological quality of the rivers (field measurements or calculated by a model) and the epidemiological data.

4. It is any way to comment, compare or discuss the data provided for the Seine river with other similar rivers in Europe or even USA?

We have added a paragraph in section 5.1 of the paper comparing the level of FC in the Seine river and its tributaries upstream Paris with the concentrations found in other rivers close to the Seine are (Meuse and Schelde). We have also mentioned papers reporting the impact of the treated wastewaters of large cities on the microbiological

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quality of rivers to compare with the impact of Paris on the Seine river.

5. Author should provide with more comments on alternative technoscience options to be applied in present and future Seine river scenarios. Some comments on the different options for waste water disinfection should welcome since UV is the only alternative mentioned in the paper and today other options exist and are applied. Examples may be the Zenon membrane bioreactors (http://www.zenonenv.com/about) or the electrochemical disinfection of urban waters.

The authors agree on the fact that other technologies (membrane bioreactors, electrochemical disinfection) than UV disinfection exist presently for an efficient removal of faecal micro-organisms. However, these technologies were not tested in the present study. The following sentences (including references on the efficiency of the alternative treatments) were added in the revised ms on this topic: “Presently, other technologies than UV disinfection exist to efficiently remove faecal micro-organisms. For example, the efficiency of membrane bioreactors (Ottoson et al., 2006) and electrochemical disinfection (Diao et al., 2004) were demonstrated but these technologies were not tested in the present study.”

Management comments

1. A current dilemma in risk analysis today is to what extend the risk communication to the public in general may protect the consumer. An already known phenomenon in risk analysis is the amplification or attenuation reactions of the consumer once the risks have been communicated (see The Social Amplification of Risks, Edited by: N. Pidgeon et al., Cambridge University Press, UK, 2003 and others). To what extend the model and its output in combination with the epidemiological data may be used to assess the amplification or attenuation processes in risk analysis?

Although this question is a very interesting one, it lies outside the scope of this paper.

2. The authors in its final section 6 “Conclusions”, open a hot but unavoidable debate

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today: how the society will resolve the dilemma of requesting for a clean environment but on the other hand increasing the pollution? The current techno-sciences are sufficient to provide a solution of the problem? Is the society aware about the economic cost of these strategies?

Clearly, the technical solutions for restoring microbiological quality suitable for bathing activities do exist. However these technical solutions are quite expensive and thus their cost might enter into competition with other priorities. The example of the recently opened bathing area in the Marne river at Meaux, upstream from Paris, is discussed in the conclusion of the paper.

3. Considering that water treatment technologies requires substantial amounts of energy and an energy crisis is soon likely, to what extend the energy will became a limit in water treatment options? The energy limits to water treatment options, would the consequence of the price or the scarcity of the energy in the future?

Energy costs represent roughly one third of the total costs of UV disinfection so that it is indeed very sensitive to a possible increase of energy price in the future.

4. Since the two basic elements that are the main driving forces for the contamination of free waters are: i) the density of the population in the studied area. It is obvious that the population growth and in particular the density growth of the urban areas is a major factor and ii) the increase in water consumption per capita in home activities as personal care, house cleaning, gardening and others, the question is: should or should not be adequate to discuss about the limits and potential control of the population density in future towns? Or perhaps the debate needs to address the limits and control of water consumption? Or may be the debate is about the limits of the water and energy consumption? Or may a combination of all of them?

Note that presently the population in the Seine basin is no more increasing and the water consumption per capita is on the decreasing side.

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5. Could the authors provide more comments on alternative technoscience options to be applied in present and future Seine scenarios. Some comments on the different options for waste water disinfection will be welcome since UV is the only alternative mentioned in the paper and today other options exist and are applied. Examples may be the Zenon membrane bioreactors (http://www.zenonenv.com/about) or the electrochemical disinfection or urban waters and others.

Possible technologies, other than UV disinfection, to increase the microbiological quality of treated wastewaters are mentioned in the revised ms (see also above the answer to general comment 5).

6. To what extend the roots of the dilemma is the citizen's behaviour that their consume habits will not be sustainable soon ?

In the particular case of faecal pollution, the only factor affecting the per capita release of pollution is the degree of collection of domestic wastewater by sewer networks. In urban environments, this system ("tout-à-l'égout") has been generalized from the end of the XIXth century on, and is now considered as the best sanitation solution, provided that adapted end of pipe wastewater treatment processes are operative. In rural area, individual treatment of wastewater is generally preferred because of the cost of installing sewer networks in less densely populated areas.

Answers to the comments of reviewer 2:

General comments

1. The absence of uncertainty assessment in the model results, taking into account the sensitivity analysis for daily specific load per inhabitant, rural specific loads per km2, FC settling and decay kinetic constants.

In order to put in evidence the variability of the daily loads per capita of treated wastewater and rural specific loads, vertical bars indicating the range between minimum and maximum measured values were added in Figure 2a and 3. We agree that in view of

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this variability, the results of the model calculation have a corresponding uncertainty. We have mentioned this fact in the revised text: "Note that the model considers average and constant specific point and diffuse loads of FC, although as shown in Figures 2a and 3 these loads display some variability which causes scatter in the field data. The model thus smoothes the observed variability displayed by the field measurements."

2. While modelling present situation, the absence of discussion of the respective variation of measurements around their annual averages, and of uncertainty of model results: are the differences significant?

Whenever possible, the range of variation of field data has been represented (see answers to specific comments below).

3. The absence of comparison of Seine River microbiological contamination to other significant European and world rivers.

See above the answer to specific comment 4 of reviewer 1.

Specific comments §2.2 FC enumeration method: Authors should provide analytical data for the described method, e.g. precision, limit of detection and quantification... both for their own results and for those obtained by water authorities in section 5.3.

The membrane filtration technique on TTC Tergitol agar medium was used both by the authors during their research activities presented in this paper and by the different authorities in charge of microbiological quality measurements (see sections 5.1 and 5.3). The detection limit of the method was 10 FC (100 ml)-1 and the coefficient of variation was estimated at 30 % based on series of replicates. These information's were added in the section 2.2 of the "Material and methods".

§3.1 Microbial pollution brought by wastewaters: Besides the daily specific loads per inhabitants in treated wastewater, values for raw wastewater could be beneficial to the reader (presently only shown on Fig.2a); both loads should be given together with their variability range or standard deviation.

The average specific load for raw water (8 x 1010 FC inh-1 day-1) is mentioned in the text (section 3.1) and is visible in Fig. 2a. In the revised version of the ms, the range of values from minimum to maximum has been indicated by vertical bars for each type of treatment in Figure 2a as suggested by the reviewer.

§4 Model: Even if the microbiological quality model has been already published, the values of the key parameters (point and non-point sources, settling and decay kinetic constants...) should be given in this manuscript.

The following information's concerning the decay rate constant and the settling rate were added n the revised ms as asked by the reviewer. "A first order disappearance rate of 45 x 10-3 h-1 at 20°C was considered for all rivers of the drainage network; this first order decay rate varies with temperature following a sigmoid relationship. For calculating the settling of FC, an average sinking rate of 0.02 m h-1 was used. "

§5.1 Present situation: can you explain how the "averages for the summer 2003 situation" were obtained through model calculations?

As explained in section 4 of the paper, the model calculates average values of FC concentration per 10 days period. The values of model calculation presented in Figure 6 are the averages at all the stations along the profile of the 9 decades between beginning of July to the end of September 2003. This information was added in the text (end of the first paragraph of section 5.1).

Technical corrections p.1155 l.16: "DNA chips" instead of "DNA cheaps"?

In the revised ms, the term "DNA microarrays" has been used. This term is the one used in the publication quoted in reference on this topic in the ms (Lemarchand et al., 2004).

p.1162 l.28: No reference for "Menon et al., 2003".

The reference to the paper "Menon et al., 2003" has been added in the reference list of the revised ms.

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p.1164 l.2 & 3: Place commas for number larger than 1,000.

In the whole revised ms, a comma was added for the numbers higher than 1,000

p.1170 l.25 & p.1172 l.26: Should titles of documents in French be translated into English?

Following the instructions given by the editor to the authors, the titles of the documents in French, which are mentioned in the paper, have not to be translated in English.

p.1174 Table 1: Introduce abbreviations when used in the text e.g. TC, FC... Would 'Restrictive' be more appropriate than 'Imperative'? Introduce commas when figures larger than 1,000.

The abbreviations TC and FC have been used in Table 1 in the revised ms. The term "Mandatory values" has used instead of "Imperative values" as this term is the one used in the European Directive. Commas were added for the numbers higher than 1,000.

p.1175 Table 2 footnote: Why note (a) is differently expressed than in Table 1?

This has been modified; the foot note "a" used in Table 2 has also been used in Table 1.

p.1177 Fig.2a: Mean specific loads values should be presented with standard deviation or range values and the legend should indicate the number of values which have been collected and averaged.

The range of values from minimum to maximum has been indicated by vertical bars for each type of treatment in the Figure and the number of samples considered for calculation of the geometric means has been indicated for each type of treatment in the legend of the figure.

p.1178 Fig.3: Why "Abundance of FC" has been preferred to usual "FC concentration"? Geometric mean values should be presented with standard deviation or range values,

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and the legend should indicate the number of values which have been collected.

The term “FC concentration” was used instead of “Abundance of FC” in the revised ms. The number of values used to calculate the geometric means has been indicated in the legend for each category of small streams considered. Vertical bars indicate the range between minimum and maximum for each category of small streams considered.

p.1179 Fig.4: Either the legend or the figure could explicit the main features/processes of the FC module, e.g. sources, settling, decay...

The sources of FC considered in the FC module as well as the processes taken into account in this module are now described in the legend of Figure 4. “The sources for the FC module are the point sources (release of FC by WWTPs effluents: calculated by multiplying the capacity of each WWTP by the corresponding specific load of FC per inhabitant and per day (Fig. 2a) depending on the type of treatment applied) and the diffuse sources (calculated on the basis of land use ((forests, cultivated, grazed and urban areas) in all elementary sub-basins of the watershed and the release of FC due to surface runoff and soil leaching on each type of land use estimated in this study (Fig. 3)). The processes affecting the fate of faecal bacteria in the FC module are the decay (first order rate kinetics with the first order rate constant depending on temperature) and the sedimentation (characterised by the sinking rate).”

p.1180 Fig.5 legend: It may be worth giving the usual precision of FC determinations when performed by Mangerel or by SIAAP, SEDIF-CGE and SNS authorities/institutions.

The data of Mangerel (1969) are not presented in Fig. 5 but in Fig. 8b (see author reply concerning this figure here below). Concerning the data of FC concentrations estimated by SIAAP, SEDIF-CGE and SNS authorities/institutions and presented in Fig. 5, they were obtained by the enumeration method described in the Material and Methods section (Plate count on TTC-Tergitol agar medium); the precision (coefficient of variation) of the method is now indicated in this section of the paper.

p.1181 Fig.6: Same comment as for Fig.3 for the use of "FC abundance". Standard deviation of field data should be presented in the graph and the number of samples given in the legend. For better understanding of the graph, vertical arrows should indicate major sites/cities on the Seine River.

The term “FC concentration” was used instead of “Abundance of FC” in the revised ms. Vertical bars indicating the range between minimum to maximum values are plotted for the field data in the Figure and the number of field data collected are indicated in the legend. Vertical arrows indicating Paris, Poses dam (the entrance of the estuary) and the main Seine Aval WWTP were added in Figure 6.

p.1182 Fig.7: For better understanding of this map, major cities of the Seine River basin should be indicated. The selection of colours does not allow their easy discrimination when the document is printed in black!

Location of major cities has been added in Figure 7. The figure will appear in colour in the publication

p.1183 Fig.8a: Legend of the Y axis: "Population and treatment capacity...". The legend of the Y axis was modified as suggested by the reviewer.

p.1183 Fig.8 legend: Give, at least in the legend, the standard deviation of the annual averages, for both periods.

The old publication of Mangerel (1969) gives only average annual data without any indication on the precision of the method used for enumeration, so the authors can not give this information. Concerning the data of FC concentrations estimated by SEDIF-CGE at the Choisy-le-Roi station, the data presented in Figure 8 are average of measurements performed weekly. The range of fluctuations around the average can be visualised in Figure 5 in which all the data collected over a one year period (2003) are presented for the Choisy-le-Roi sampling station.

p.1184 Fig.9a: Legend of the Y axis: "Population and treatment capacity..." For better

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understanding of the graph, vertical arrows should indicate major sites/cities on the Seine River.

The legend of the Y axis in Fig. 9a was modified as suggested by the reviewer. Vertical arrows indicating Paris, sewer outfall in Clichy and the Seine Aval WWTP were added in Fig. 9b.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 1153, 2007.