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Abstract

This bibliographical study falls under the context of researching financial autonomy for durable management of South countries' wastewater ponds (WSP), and growing interest on shellfish zooplanktons that contribute to water treatment and can be recovered in aquaculture and many industrial applications. Our project will start by gathering available data aiming at the development of a mathematical model of the contribution of zooplankton in pond ecosystems. This model would include the effect of most driving factors on the growth of shellfish zooplankton in WSP combined with water treatment efficiency and biomass productivities.
After a description of various types of WSP and their corresponding zooplanktons, emphasis is put on the shellfish cladocerans, especially Daphnia. The range of growth rates in various conditions is provided and expressions of growth kinetic, merging the effect of most important factors identified. These expressions of kinetic and the corresponding stoichiometry will serve as a first approach in our model.
We hope that this type of research will help in the development of sustainable sanitation systems in developing counties.

Keywords

Developing countries, zooplankton, modelling, waste stabilization pond, re-uses.

INTRODUCTION

Public health concerns continue to be alarming in developing countries because of a bad management of waste, a financially non-profitable character of sanitation projects and limited financial means. Those are then often obliged to relegate illness prevention by sanitation to the second plan, in favour of curative health. In order to help reducing the world's population deprived of access to sanitation, reflection is being developed about the means of combining waste water management with the valorization of some of its products. The aim is, to durably solve sanitation problems in Southern countries by promoting installation and management of financially autonomous WSP. To achieve this, besides its adaptation to the socio-economic and climatic contexts (PIETRESANTA and BONDON, 1994; KONE, 1996), WSP system offers these means while presenting, in addition to purified water (SEIDL and MOUCHEL, 2003), algae (DEKAYIR, 2004), a zooplankton which is re-use (CAUCHIE, 2000) in various fields (pharmaceutical and agro-alimentary industries). It is being studied about its productivity; however, few studies rarely take into account its real contribution to the treatment of waste water.

The present bibliographical study aims at the global objective of contributing to the search of efficient solutions ensuring the financial autonomy of WSP in Southern countries and creating sources of wealth. It has two specific aims: first, gather the available data in order to model not only the production of zooplankton but also its contribution to waste water treatment in WSP; then identify expressions of kinetics and stoichiometry of growth. This report first reminds the various WSP systems and their characteristic zooplanktons, then presents the available data to carry out modeling, and finally presents the growth kinetics expressions in sanitation engineering language.

METHOD

To undertake this work, we followed the gradual approach consisting successively to height steps described below:

Define the objectives of our information retrieval (here: to mobilize the available data on the ecology of the WSP zooplankton and to identify studies on the modeling of the zooplankton)
Formulate an initial question (here: the modeling of the production of zooplankton shellfish in WSP)
Define concepts
(Object: zooplankton shellfish; Subject: Modeling of watery biological systems; Context of production of these shellfish: waste water purification in WSP)
Seek descriptors and keywords and define conceptual fields (by using the encyclopedia universalis and the thesauri AGROVOC and Eurovoc, the Thesaurus of the AFSA, the Thesaurus of UNESCO, and the Thesaurus of the GEMET-EIONET).
What made it possible to obtain
For object: copepods, cladoscères, zooplankton, crustacean, zooplankton, plankton, shellfish, Plankton.
For subject: Mathematical modeling; Environmental modeling, Environmental modelling; Simulation, modeling, Modeling.
For context of production of these shellfish: lagunage, treatment of waste water, water treatment, waste water treatment, lagooning, waste stabilization pond.
Define the relations between the conceptual fields

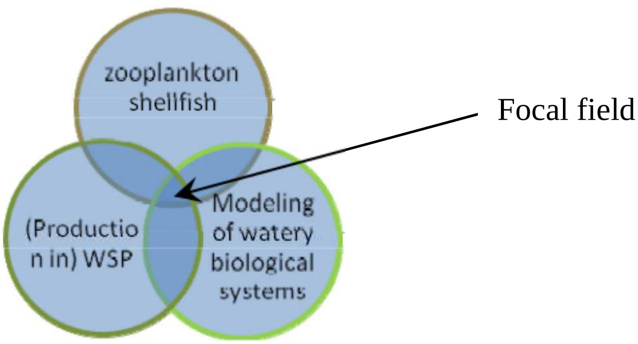

Figure 1: Illustration of the relations between the three concepts

Draft the documentary question
Copepod or cladocere or zooplancton or crustacean or zooplankton or plankton or crustace or Plancton AND Modelisation mathematique or Modelisation environnementale or modeling or simulation or environmental modelling or modélisation or modelling AND Lagunage or traitement des eaux usees or traitement de l'eau or waste water treatment or lagooning.

NB: In certain documentary systems we were obliged to remove the French terms and expressions before being able to obtain results.

Application of the documentary question in the documentary tools (SciencesDirect, ISI Web of Knowledge, OAlster, catalogs of University of Liege)
Selection of the documents successively on the basis of reading of the titles, the summaries then whole document

RESULTS AND DISCUSSION

Various types of WSP and their corresponding zooplanktons

Waste stabilization pond
Specialized literature reports that several water treatment processes (with their characteristics) are gathered under the term "waste stabilization pond". PIETRESANTA and BONDON's (1994) proposal of classification, among others, distinguishes:

- Facultative stabilization pond,
- Aerated waste stabilization pond,
- Anaerobic pond,
- High-rate algal pond (HRAP)

VARON and MARA (2004), also add the maturation pond which, main function is the abatement of pathogenic germs, but also improves the abatement of organic loads.

<u>Facultative stabilization pond</u>
Facultative stabilization pond can be with microphytes, macrophytes or composite, and is characterized by its biological diversity including both aerobic and anaerobic organisms.

When this expression is employed to indicate a pond, it generally refers to the facultative stabilization pond in which three zones differing in their oxygenation conditions coexist. Treatment is naturally carried out by mechanisms using sedimentation, biological degradation and inter and intra-specific relations between various groups of organisms. This complex mechanism of operation can be illustrated by the figure 2 below:

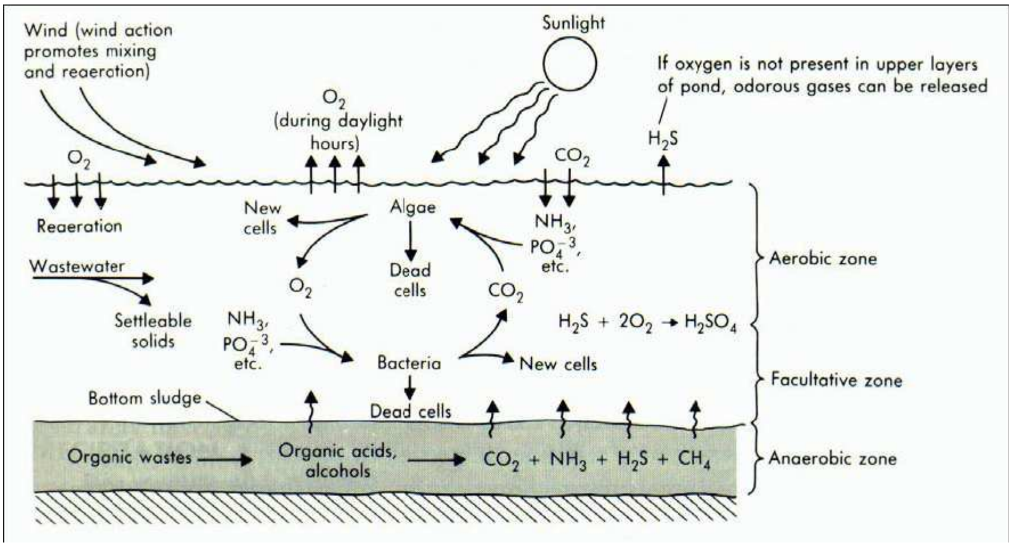

Figure 2 : Diagram of operation Facultative stabilization pond (Tchobanoglous et al., (1985), cited by Shilton, European commission).

In the upper layer, oxygen is brought, on the one hand, by the diffusion starting from the atmosphere, and on the other hand, by photosynthesis. This oxygen allows the development and the maintenance of a whole aerobic flora including zooplankton and aerobic bacteria which degrade the organic matter releasing carbonic gas and nutrients which are useful for plants growth.
In the sediments, the anaerobic conditions favour the anaerobic bacteria which release after digestion, carbonic gas and methane. Between the two limits, conditions can be anoxic in a zone which depth can vary according to the airing conditions and sediments accumulation.
Unfortunately, this figure does not consider zooplankton which naturally colonizes these ponds.

When the expression "WSP" is employed to indicate the type of station, one generally observes the placing in one or more series of anaerobic, facultative generally followed by maturation ponds according to the desired quality of the purified water (VARON and MARA, 2004).
Concerning the macrophytes like Eichornia, Typha and Phragmites, REDDY *et al*. (1987), BRIX *et al.* (1989), and SEKIRANDA *et al.* cited by SEIDL *et al.* (2003), estimate that they can significantly improve the effluent quality in several ways : extraction of the nutritive elements of the water column; fixing of the purifying micro-organisms on their roots and leaves, limitation of the development of microscopic algae difficult to decant, reduction of the evaporation of treated water (ORON *et al*. 1987 cited by SEIDL *et al*. 2003). However, these authors deplore the fact that it decreases the re airing of the water column and the treatment effectiveness regarding the indicatory pathogenic species.

<u>Other types of waste stabilization ponds</u>

Table 1 below describes the three other WSP types by comparing them with the facultative pond according to five principal criteria presented in the left-hand column. It shows that only anaerobic and facultative ponds can be truly regarded as "natural", adapted to the economic context of developing countries and are particularly interesting within the framework of this study. The two other alternative ponds lead to a mechanical intervention for their airing and mixing, which energy expenditure would be difficult to support by developing countries.

Table 1: Description of the four types of WSP

CHARACTERISTICS	TYPE OF WASTE STABILIZATION POND				REFERENCES
	Facultative stabilisation pond	Aerated waste stabilisation pond	Anaerobic pond	High-rate algal pond	(1) FINNEY et MIDDLEBROOKS (1980) cited by CAUCHIE(2000)
Biological component	algae Various bacteria, zooplankton	Aerobic bacteria Few algae, Zooplankton	Very few or not algae, Anaerobic Bacteria	Very strong algal biomass, Various bacteria, little zooplankton	(2), (6) MARA *et al.* (1992) cited by CAUCHIE (2000)
Airing mode	Photosynthesis, Diffusion with the water-air interface	Mechanical aerators or Blowers	Diffusion with the water-air interface	Aerators (paddle wheel) or Blowers	(3), (7) SAQQAR et PESCOD (1995) cited by CAUCHIE (2000)
Mixing mode	The flow and wind (on the surface)	Mechanics	The water run-off and the agitation of surface by the wind	Paddle wheel	(4)
Treatment mechanism	Sedimentation, Aerobic, anoxic and anaerobic degradation Predation	Aerobic degradation, Predation	Sedimentation, Degradation mainly anaerobic, Predation	Aerobic degradation, Predation	(8) OSWALD (1963) cited by CAUCHIE (2000)

Loads	(1) 10-40 g $BOD_5/m^2.j$	(2) 40 à 100g $BOD_5/m^2.j$	(3)>100 g $BOD_5/(m^3.j)$	(4) 80-160	(5) MARA (1995) cited by CAUCHIE (2000)
Depth	(5) 1 to 2 m	(6) <50 cm	(7) 2 to 7 m	(8) 30 to 60 cm	

In these biological waste water treatment processes where algae take a considerable place, the treatment performances often appear contestable if one considers the presence these algae in the purified water. Their sizes are so small that it is not yet possible (under natural conditions and in the context of developing countries) to retain them before purified water rejection. Therefore, the role of zooplankton as a natural grazer of these algae and other particular organic matters appears to be very important in these water treatment processes.

WSP zooplankton ecology

Four independent groups compose the essence of WSP zooplankton: protozoa, rotifers, copepods and cladocerans, (PIETRESANTA and BONDON, 1994).

The synthesis of writings shows that the distribution of WSP zooplankton groups is strongly governed by physicochemical and nutritive conditions. Except Copepods, each other group appears to be more adapted to a given pond, as it is shown in table 2. This WSP characteristic can be explained by the relative stability of its conditions, without considering climatic factors (particularly temperature and precipitations) which can influence the speed of the microbial activity, algal blooms and food concentration.

Table 2: Outline on the ecology of WSP's zooplankton

CHARACTERISTICS	GROUPS			
	Protozoa	Rotifers	Copepods	Cladocerans
Size	20 - 50 µm	40 - 80 µm	0,5 - 3,5 mm	0,2 - 3 mm
Food	Bacteria	Bacteria, protozoa, algae	Bacteria, protozoa, algae, (rotifers and cladocers for high species)	Bacteria, protozoa, algae; Particulate organic matters
Mode of reproduction	Sexed Asexual	asexual in favorable conditions; sexed in adverse	Sexed	asexual in favorable conditions; sexed in adverse conditions
Population	Not sexually differentiated	Ovoviviparous females Males in adverse conditions Eggs of resistance (adverse conditions)	Oviparous females Males Eggs of resistance (adverse conditions)	Ovoviviparous females Males in adverse conditions Eggs of resistance (adverse conditions)
Dynamics	None	[1] Seasonal	Seasonal	Seasonal
Localization	[2] All ponds (except in winter the last basins)	[3] 1^{st} pond; Weak density in oligotrophic water, Strong density in eutrophic water	[4] Rare presence in WSP	Especially in the last basins
Predominent kind	Not announced	Brachionus	[5]Cyclopoids	[6] *Daphniids 75 to 95% of the biomass of zooplankton in eutrophic basins (in certain cases Moiniids)*

[1] PIETRESANTA and BONDON (1994)
[2] PIETRESANTA and BONDON (1994)
[3] (POURRIOT (1965), cited by KHATTABI et al. (2001)
[4] PIZAY-PARENTY (1985) cited by CANOVA (1991) and KONE (1996)
[5] KONE (1996)
[6] TIFNOUTI et al. (1989) and KHATTABI (2002)

Available data for modeling

Independent factors influencing the activity of daphnids

The comprehension of these various factors which influence zooplankton growth is of fundamental need, with a view to optimize their contribution to water treatment and their possible production for valorization ends.

Food

Relative place of bacteria in daphnids food

Several works made it possible to understand that the bacteria do not constitute Daphnids' main food. TEZUKA (1971, 1974), PORTER *et al.* (1979) and LAMBERT cited by KONE (1996), indeed reported that the inhibition of growth observed in the daphnids in a pure culture of bacteria was not observed any more in one mixture of protozoa and bacteria.

This observation was confirmed by JURGENS *et al.* (1994), cited by KONE (1996), which noted during experiments in natural environment (lakes), that the speed of ingestion of the protozoa (2.9 individuals (L.h) was largely higher than that of ingestion of the bacteria (0.4 individuals (L.h). The same author reports that PETERSON and HOBBIES (1978) observe that the macroscopic velocity of the bacteria by the daphnids in the environment makes only 30% of the value measured with yeasts (bigger). Supporting the preceding observations, the author also cited LANGIS *et al.* (1985) which established that besides being used as food by daphnids, bacteria contribute in a qualitative way to their food by providing chemical substances (amino-acid, fatty-acids and vitamins) necessary for daphnids' growth and reproduction on the one hand and on the other hand, by supporting the detoxication of water by nitrification of ammonia.

Relative place of algae in daphnids food

CAUCHIE (2000) showed by measuring the contents of lipids which indicate nutrition state of daphnids that those ones feed themselves well in an aerated WSP despite of the absence of algae. Considering an ecological growth yield of D. *magna* of 20%, in accordance with MacFADYEN (1964), he found that all in all bacteria and algae would constitute only 3 to 20% of food quantity necessary to support daphnids' growth in the aerated WSP which he studied. He thus established that the daphnids could also feed themselves with dead particulate organic matters of reduced size and the nano zooplankton.

With regard to the particular group of algae which the cyanobacteries constitute, De BERNADI and GIUSSANI (1990), DAWINDOWICKZ (1990) and GLIWICZ (1990) cited by KONE (1996) confirmed the assumption that contrary to the cyanobacteries of small size which can be grazed as long as they are not gathered, the species of big size which develop when the conditions are favorable block the apparatuses filterers of the daphnids when they are grazed without being fragmented in small filaments. Moreover the toxic substance secretion by the cyanobacteries for their periods of bloom would be at the origin of the disappearance of the zooplankton for these periods. According to De BERNADI and GIUSSANI (1990) cited by CAUCHIE (2000), it is possible that toxic species and other without toxic effect belonging to the same kind coexist.

Physicochemical conditions of the medium

The season

The season's influence on the dynamics of zooplankton in general was evoked in many studies. Those ones point out that, zooplankton populations are weak in winter because of low temperatures; they are important in spring when the phytoplankton is dominated by the easily ingested forms, and they regress in summer because of an increase in the photosynthetic activity which supports algal

bloom and toxic secretions due to cyanobacteries. This zooplankton populations' dynamics in WSP during various seasons is thus explained by different tolerances in physico-chemical conditions.
LOEDOLFF (1965) cited by TIFNOUTI (1989), observes that M. *micrura* is the most abundant cladocerans in a primary oxidation pond whereas D. *magna* dominates in the secondary and tertiary oxidation ponds. In the same way, DINGERS (1973) cited by ANGELI (1979) and TIFNOUTI (1989), observes the replacement of daphnids by moinids in the WSP of Texas, when the pH and the content in NH_4^+ becomes high.

C:N:P ratios
The C:N:P ratios of the organisms compared to that of the medium also influence the zooplankton growth and the dynamics of its populations. To maintain their homeostasis, these organisms get rid of excesses of nutritive elements (C:N:P) compared to their needs, by various physiological mechanisms (HESSEN, 2005). The importance of the quality of food through its C: N: P ratio was also evoked by WU and CULVER (1994) which showed while working on Daphnia *pulicaria*, that the food quality is quite as important as its quantity in the determination of fruitfulness, and finally that the balance of the nutrients is more important than the absolute abundance of any of those.

Oxygen content
The capacity to synthesize hemoglobin that certain species of daphnids have, enables them to live longer, to swim more quickly, to increase their filtration and ingestion rates, and to increase their eggs production as well as the development of their embryos (FOX, 1951). In agreement with these results, SELL (1998) showed that the adaptation of zooplankton shellfish to low oxygen contents varies according to the species, their relative wealth in hemoglobin and pigments to strong affinity with oxygen. The species with low capacity of hemoglobin synthesis such as D. *rosea*, are affected considerably by the low oxygen contents, with a consequent reduction in their growth rate and reproduction.

Total ammonium content and pH
The influence of total ammonium (NH_3 + NH_4^+) lies in its toxicity, starting from certain concentrations under precise pH conditions. van de Vorstenbosch (2005) showed that to be compatible with the zooplankton's normal growth, ammonium total content of will have to satisfy the following conditions: to be lower than 15 mg/L with pH close to 8 or, to be lower than 5mg/L for pH superiors to 8.5.

Temperature
MYRANDE and De la NOUE (1982) showed that in not-limiting food conditions, temperatures higher than 15°C are favorable to a fast increase in biomass of daphnids. These observations are also confirmed by TIFNOUTI and POURRIOT (1989) and CAUCHIE (2000).

Modeling works on WSP zooplankton
One of the practical tools for the management of a complex biological system such as WSP is incontestably, the modeling. Deterministic models have the advantage of being based on the description of processes which are summarized in mathematical equations.

Within the framework of this bibliographical study, two deterministic models were found in the literature concerning (directly or not) the modeling of the zooplankton in WSP. These are: Daphnia population model (HATHAWAY and STEFAN, 1995) and River Water Quality Model n°1 developed by "International Water Association" (IWA).

Daphnia population model (HATHAWAY and STEFAN, 1995)

Proposed to evaluate daphnia population, it is integrated into a WSP model adapted from an original model designed for lakes and named “MIN-LAKE”. In agreement with the influences of oxygen, ammonia and algae raised by several authors, it introduces new influences as the toxic effect of hydrogen sulfide, the resistant eggs hatching, the clearing out of ponds, and the predation. This model considers, the evolution of daphnids population in WSP as the balance between the terms of growth (from individuals born by parthenogenesis and those born by sexed way) and the terms of disappearance (due to the clearing out of the pond when this one is filled of sediments, the water toxicity, old age, and the loss of mass by endogenous respiration), across the whole depth of the basin.
However, the model doesn’t consider the consumption of particulate organic matter, bacteria and protozoa, also mentioned in the literature. It does not consider either the tissue growth related to the increase in size (and weight) of the organisms. It seems thus, not to allow rigorous matter assessment with the possibility of evaluating the impact of daphnids (or other zooplankton groups) on water treatment.

<u>River water quality model n°1 (RWQM1)</u>
This model is designed for integrated management of river water quality. It primarily describes the biochemical conversion processes and offers the possibility of being adapted to practical cases by restriction amongst variables which it proposes. It adopts model presentation formalism with stoichiometric and kinetic equations in Petersen’s matrix. It supposes a constant biomole, the same growth and death rate for them. It does not bring precision on the type of growth (weight or sexed or asexual reproduction), and on the type of death which it considers. Neither does he consider certain processes taken into account by the model of HATHAWAY and STEFAN (1995).

Table 3 shows a synthesis of a comparison of these two models on the basis of four processes (growth, disappearance, clearing out of pond, and sedimentation) and three substrates (algae, bacteria and protozoa). The plus sign (+) indicates the considered elements by a model and the minus signs (-), those not.

Table 3: Comparison of RWQM1and Daphnia population model

Comparison criterion			Daphnid population (HATHAWAY and STEFAN, 1995)	R.W.Q.M. n°1 (IWA task group, 2001)
Biochemical conversion process	Growth	Ponderal	-	+
		Parthenogenetic	+	+
		Sexed reproduction	+	-
	Disappearance	Toxic effect	+	-
		Death	+	+
		Endogenous respiration	+	+
		Predation	+	-
Physical process of disappearance	Clearing out of pond		+	-
	Sedimentation		+	-
Substrate		Organic particulate matters	-	+
		Algae	+	+
		Bacteria	-	+

This table highlights the complementarity of these two models, with respect to our objectives (specified above) and justifies our choice to combine them for our application (see conclusion).

Other available data for modeling

The figure 3 illustrates principal interactions between the components of a facultative WSP ecosystem. Its comment is the same as in figure 2, if one is unaware of what is held in the sediments.

It shows that apart from state variables (food quantity and quality, dissolved oxygen contents, ,…), of which we already saw the influence on the activity of the daphnids, the data which remain to be mobilized for the modeling primarily relate to the kinetics and stoichiometries of biochemical conversion processes (well described by HATHAWAY, 1995 and IWA Task Group, 2001).

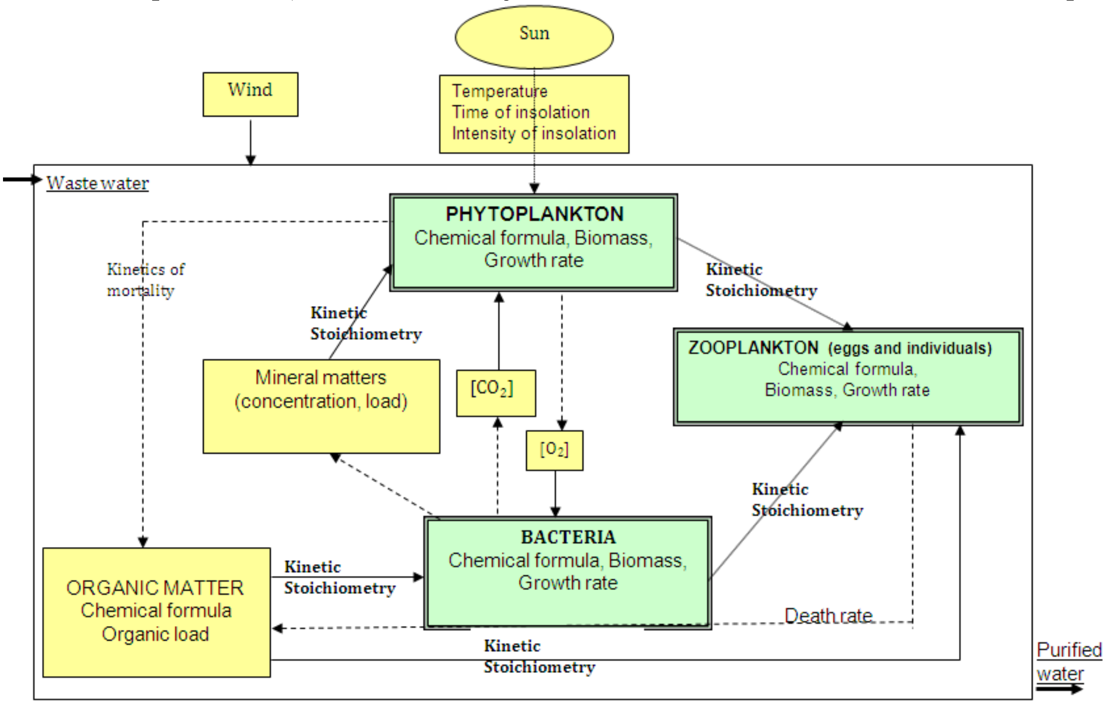

Figure 3: Conceptual model of WSP illustrating various interactions of ingestion/ luminous and wind regulation (solid line) and rejection (in dotted lines) between abiotic components (yellow rectangles) and biotic components (green rectangles) and highlighting stoichiometric and kinetic parameters related to zooplankton growth.

For these conversion processes, research of the orders of magnitude, parameters of growth and conversion available in the literature is necessary to allow us, to carry out judicious comparisons of the values which we will measure during our work at the laboratory and on the field.

The data found in the literature are presented in the following tables (4 to 7). They are not easy to compare because the experiments were often carried out on different species, under different conditions of experimentation and with different techniques of analysis. Within the limits of research which we carried out to date, few of it relates to the WSP of developing countries.

The table 4 shows the great variability of the biochemical composition of the daphnids according probably to the aging and the living conditions of these organisms. But the variability of the technics of analysis implemented also contributes to this variability of the results.

Table 4: Average biochemical composition of ***Daphnia magna***

Reference	Proteins (mg/g dry weight)	Lipids (mg/g de poids sec)	Mineral matters (mg/g dry weight)	Carotenoids (µg/g de poids sec)	Chitin (mg/g dry weight)

*FARKAS (1958)	223	346	-	-	-
*BLAZKA (1966)	680	131	-	-	-
CZECZUGA (1984)	-	-	-	4	-
PARTALI *et al.* , (1985)	-	-	-	25 - 237	-
McKEE et KNOWLES (1987)	477 - 620	64 - 179	-	-	-
ELENDT (1989)	263 - 566	57 - 128	-	-	-
De MEESTER et BEENAERTS (1993)	-	-	-	250 - 457	-
CAUCHIE (2000)	186 - 397	65 - 171	100 - 327	37 - 246	30 - 70

The elementary carbon, nitrogen and phosphorus contents of daphnids is given by ANDERSON, HESSEN and *al.* (2005), as follows: C/N = 5,9 molC/molN, C/P = 86,8 molC/molP, N/P= 14,7 molN/molP.
The table 5 illustrates the variability of productions in the time and rather shows a growth in the case of the data of CAUCHIE (2000).

Table 5: Some orders of magnitude of production and production rate

Species/ pond (locality)	Somatic and egg annual net production	exuvial net production rate	Annual net production of exuviae	Total net production	Reference
	dry weight/(m^2.year)	% of somatic biomass/day	dry weight /(m^2.year)	dry weight /m^2.year	
D. *magna* / Aerated WSP (Grand-duché of Luxembourg)	220,3 in 1994 422,5 in 1995 442,1 in 1996	20 to 40 % of daily net production	67,5 in 1994 145,1 in 1995 150,8 in 1996	287,8 in 1994 567,6 in 1995 592,9 in 1996	CAUCHIE, (2000)
D. *magna* / facultative WSP (Australie)	-	-	-	139,2	MITCHELL et WILLIAMS, (1982) cited by CAUCHIE, (2000)
Daphnies/Facultative WSP (Mèze)	-	-	-	83,g/(m^2.month) from May to October	ARGENCE cited by BARNABE (1983)

The table 6 shows that the demographic growth rates obtained on synthetic medium are always higher than those obtained under field conditions.

Table 6 : Some orders of magnitude of birth rate, death rate and growth rate

Species / medium	Biomass (dry weight /m^2)	Birth rate (day^{-1})	Instantaneous growth rate of the population (day^{-1})	Death rate (day^{-1})	Reference
D. Magna / aerated WSP	4in 1994 10 g in 1995 30 in 1995	< 0,2 in 1994 > 0,15 from July to October in 1995 < 0,2 j^{-1} in 1996	- - -	] 0,05 ; 0,2[	(CAUCHIE, 2000)
Daphnies/ algal substrate	-	-	0,33	-	(van de VORSTENBOSCH, 2005)
Moina micrua/ Synthetic medium	-	-	1,19	-	(PAGANO, 2000)
Moina micrura / Tanks of 4 m^3	-	-	0,67 to 0,92	-	
Diaphanosoma	-	-	0,78	-	

Excisum/ Synthetic medium				
Diaphanosoma Excisum / Fertilized basins from 100 to 500 m^2	-	-	0,3 to 0,5	-

Source : CAUCHIE (2000)

The table 7 shows some orders of magnitude of ingestion rate and filtration rate of algae and bacteria by Daphnia magna under various conditions.

Table 7: Ingestion and filtration rate of the zooplankton

Species /Condition	Substrate	Ingestion rate (% of Biomass /day)	Ingestion rate (% of production/j)	Filtration rate (en $L.m^{-2}.day^{-1}$)	Reference
Daphnia *magna* / aerated WSP	Phytoplankton	66 to 92 (including 171 in July)	2 to 90 (including 310 in July)	2233.3 to 3137.3 (including 5816.5 in July)	CAUCHIE, (2000)
	Bacteria	0.1 to 17,6	0,8 to 226	4 to 599,9	
Daphnia *magna* /Experimental conditions	*E-coli*	134,4 millions/hour	-	-	MacMAHON (1965) cited by (van de VORSTENBOSCH, 2005)

CAUCHIE explains connect it relative importance of the rate of ingestion of alga compared to that of the bacteria by the more considerable contributions of bacteria (through the influential one), whereas the algae are brought only by the internal production of the system.

Identified expressions for zooplankton production control parameters in sanitation field

In order to identify the expressions of kinetics and stoichiometry to be used for the zooplankton in our model which has as a basis, the RWQM1 already used for the phytoplankton within our research unit (directed by professor Jean-Luc VASEL), we used the complementarity (raised with respect to our objectives) of the RWQM1 and the daphnia population model suggested by HATHAWAY and STEFAN (1995).

Growth rates and mortality rates

Various expressions of growth rates and mortality rates suggested in these two models are presented in table 8 which shows that, besides the complementarity observed (in regard to our objectives) between the two models (table 3) they use different expressions and different units.

Table 8 : Expression of growth rates and mortality per author

Processus	Expression of growth rates and mortality per author: IWA task group (2001)	HATHAWAY and STEFAN (1995)
Growth on substrate i (i = Algae, COP, Bacteria)	$k_{gro,CON,T_0} e^{\beta_{CON}(T-T_0)} \frac{S_{O_2}}{K_{O_2,CON}+S_{O_2}} X_i X_{CON}$	$k_{gro,Algue,CON,T_0} \frac{X_{Algue}}{K_{Algue,CON}+X_{Algue}} X_{CON}$
Sexed reproduction	-	$\frac{EPHATCH}{EGDES * A_{BOT}}$
Endogenous respiration in aerobie	$k_{resp,CON,T_0} e^{\beta_{CON}(T-T_0)} \frac{S_{O_2}}{K_{O_2,CON}+S_{O_2}} X_{CON}$	Constante * T
Death	$k_{death,,CON,T_0} e^{\beta_{CON}(T-T_0)} X_{CON}$	

Death due to the toxic effect of a high content in NH_3,	-	$\frac{e^{\alpha_{NH_3} S_{NH_3}}}{\xi_{NH_3} + e^{\alpha_{NH_3} S_{NH_3}}}$
Death due to the toxic effect of a high content in H_2S	-	$\frac{e^{\alpha_{H_2S} S_{H_2S}}}{\xi_{H_2S} + e^{\alpha_{H_2S} S_{H_2S}}}$
Death due to a small content in dissolved oxygen	-	$1 - \frac{e^{\alpha_{O_2} S_{O_2}}}{\xi_{O_2} + e^{\alpha_{O_2} S_{O_2}}}$
Death due to aging	-	$\frac{T}{7°} * Tmort$

with :

$k_{gro, CON,T}$: maximum specific growth rate for zooplankton per mass unit of grazed organisms (m^3/gCOD.d)
$k_{gro, algue, CON,T}$: maximum specific growth rate for zooplankton per mass unit of algal substrate (d^{-1})
$k_{death, CON,T}$: specific death rate for zooplankton (d^{-1})
$k_{resp, CON,T}$: maximum specific respiration rate of zooplankton (d^{-1})
$K_{O2,CON}$: saturation/inhibition coefficient for endogenous respiration of consumers ;
$K_{algue, CON}$: half saturation coefficient for zooplankton feeding on algal substrate (g/l)
α_a et ξ_a :curve fitting parameters used to regulate the shape of the sigmoid toxic mortality function (dimensionless a = H_2S, NH_3, O_2)
β_{CON} : temperature correction factor for zooplankton growth rate (°C^{-1})
S_b : Concentration in dissolved substances (b = O_2, H_2S, NH_3)
T : water temperature (°C)
T_{death} : temperature-related mortality coefficient (per day per °C)
$X_{CON:}$ content of zooplankton (COD)
X_i : content of particulate matter (i = particulate organic matters ; Algae ; bacteria)
EPHATCH: number of Daphnia released per day from ephippia
EGDENS:measured (or estimated) egg density (number per metre squared)
A_{BOT}: area of the pond sediment (square meters)

Conversion yield Y

Without being able to detail it here, it is important to notice that the RWQM1 (IWA task group, 2001) made important proposals for conversion rates relating to the zooplankton. But, those do not distinctly consider eggs and exuviae.

For the determination of the conversion rates, a stoichiometric relation based on the biomoles of each compound will be employed. Those biomoles still remains to be mobilized.

Figure 3 below illustrates the general form of such an equation:

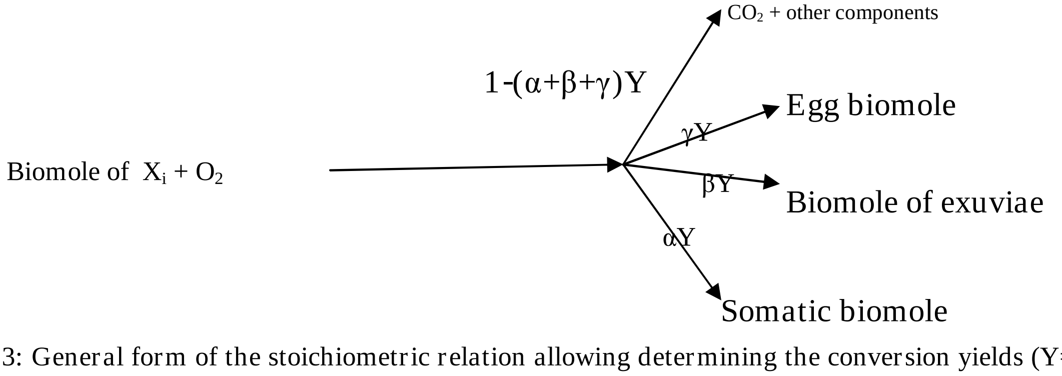

Figure 3: General form of the stoichiometric relation allowing determining the conversion yields (Y= conversion rate;   Xi= substrate (with i= Algae, particulate organic matter, bacteria) ; αY , βY et γY are respectively the fractions of substrate transformed into somatic biomass, exuviae and eggs ($\alpha + \beta + \gamma = 1$)

CONCLUSION

This bibliographical study gives a picture of the present knowledge about the modeling of WSP zooplankton and makes it possible to take orientations in order to reach the goal of modeling not only zooplankton production but also its contribution to water treatment in WSP. It shows that two models already exist which are complementary regarding our aim and can be used after the harmonization of their expressions and measurement units.

In a general way, research in progress on zooplankton and the possibilities of its valorization could indeed offer opportunity for the durable improvement of life framework in developing countries. Indeed, besides the guarantee that already offers the WSP technology to be particularly adapted to these countries, productions of zooplankton could be spread out all over the year because of stable climatic conditions. However this research needs being completed on developing countries zooplankton species with a high potential in added-value.

ACKNOWLEGEMENT

We are grateful to the government of Belgium for granting a financial support to Mouhamadou Nourou Dine LIADY for his Mixed PhD researches. The authors would like to acknowledge the Belgian Technical Cooperation which executes this financial support program for the Government of Belgium.

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