Hazardous Substances Series

Background Document on the Use of Sodium Hypochlorite

OSPAR Commission

1999

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Union and Spain.

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par l'Espagne et l'Union européenne.

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PREFACE

The 1992 Ministerial Meeting of the Oslo and Paris Commissions adopted an Action Plan for the Commissions, which set out that the Commissions will give priority to the substantial reduction of inputs to the maritime area of organohalogen substances which are toxic, persistent and liable to bioaccumulate, with the aim of their elimination.

As part of the follow-up of this commitment, The Netherlands organised in May 1995 a workshop on organohalogens within the framework of the OSPAR Working Group on Diffuse Sources (DIFF). The objective of this workshop was:

> *An exchange of information on the use and characteristics of products giving rise to discharges and emissions of organohalogens with the aim of identifying the main diffuse sources where action is needed on the basis of the precautionary approach*.

Taking into account the discussions on the outcome of this workshop held at the annual meeting of DIFF in 1995, the Commissions agreed on further work within the framework of DIFF on Best Environmental Practices for the Use of sodium hypochlorite (NaOCl) in households and as a disinfectant in swimming pools. This work, which was carried out under the joint lead countries France, The Netherlands and Spain, produced this **Background Document on the Use of Sodium Hypochlorite**, consisting of the following sections:

- **I - Best Environmental Practice for Hypochlorite Use in Households;**
- **II - Use of Sodium Hypochlorite as a Desinfectant in Swimming Pools;**
- **III - The Origin and Type of Pollutants - Environmental Effects.**

Section III outlines general information about the chemical properties of hypochlorite, its by-products (on the basis of studies carried out with respect to the treatment of swimming pool water) and its environmental effects. This section relates to a large extent to both the use of hypochlorite in households and its use as a disinfectant in swimming pools and should therefore be considered in close connection with sections I and II.

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Section I

Best Environmental Practice for Hypochlorite Use in Households

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I INTRODUCTION AND SUMMARY OF CONCLUSIONS

This background document on Best Environmental Practices (BEP) for hypochlorite use in households has been produced by the lead countries in cooperation with industry. Most of the facts and figures on hypochlorite use and products have been provided by Akzo Nobel BV, Association of the Dutch Chemical Industry, Dutch Soap Association, Lever Nederland BV and Proctor & Gamble Benelux BV.

Bearing in mind the information provided in this background document, DIFF 1997 discussed the need for establishing a BEP for the use of hypochlorite in households and agreed that such a BEP was not a matter of urgency for OSPAR. Also, OSPAR was not the correct forum to establish a BEP motivated mainly by health and safety considerations rather than by concerns for the protection of the marine environment. In conclusion, DIFF 1997 agreed that DIFF 1998 should give further consideration to the need for an OSPAR BEP for the use of hypochlorite in households, taking into account, *inter alia*, developments with respect to this issue in the EU.

Relevant developments in the EU concern the establishment of risk assessments for some existing chemicals according to Regulation 793/93. Three lists of priority substances for risk assessment are available now. Sodium hypochlorite is part of the second priority list with Italy as a lead country within the European Community framework. The results of this risk assessment study are expected to be available in the beginning of 1998.

Questions about the suitability of AOX as a parameter (e.g. the relation between AOX and hazard) are not dealt with in this document. DIFF 1996 agreed that there was an urgent need for further research into more meaningful parameters than AOX in order to identify, assess and prioritise potentially hazardous organohalogens. This issue, including the identification of the remaining unidentified sources of AOX in sewage, will be further investigated within OSPAR by the Netherlands. As a follow-up, the Netherlands carried out a literature research concerning methods which are suitable for assessing the environmental impact of organohalogens in waste water. The available information was compiled in the report ‘Fractionation and Characterisation of AOX/EOX’ and presented to DIFF 1997 and POINT 1997. This report clearly demonstrates that further work is needed to find methods to distinguish/separate the toxic effects of persistent and bioaccumulative (PB) organohalogens and other PB substances. However, this rather complex and difficult issue becomes only relevant when there is a need for ‘toxicity back tracking’. Therefore, at this stage, the development of a tool for the ecotoxicological evaluation of (complex) effluents as a whole, which is being carried out under OSPAR's Working Group on Point Sources (POINT), seems to be the more practical and convenient approach. If a (considerable) environmental impact of the whole effluent will be identified, further investigations are needed with respect to the sources of specific persistent, bioaccumulative and toxic substances (PBTs), including organohalogens. After this step, a separation of organohalogens and other substances might be necessary to identify the most appropriate measures. The AOX/EOX parameters are at this stage very useful to trace the origin of the PBTs.

II IDENTIFICATION OF APPLICATIONS OF HYPOCHLORITE IN HOUSEHOLDS

2.1 Applications under consideration for this BEP

Products based on hypochlorite are used by many consumers throughout Europe because they:

a. are multi-functional;

b. remove protein, starch and polymerised oil residues;

c. bleach stains from surfaces and laundry;

d. take care of obnoxious smells; and

e. are powerful, wide-spectrum disinfectants.

There are several types of products on the market. By far the largest volume is taken by products formulated with 3-5 % hypochlorite, often called "bleaches". These are available with or without added surfactants to enhance the cleaning efficiency and wetting. The viscosity of the products with surfactants may be considerably higher than plain hypochlorite products. This provides increased contact time and an undiluted application on vertical surfaces, e.g. inside toilet bowls.

A smaller share (up to 5 %) in most European markets is taken up by specialist products, formulated with 0,5-1,5 % hypochlorite. In general, these are "general purpose cleaners" with the added benefit of providing bleaching and hygiene throughout disinfection.

The percentage of use of "bleaches" (with or without surfactants) in various European countries is given in table 2.1.

Table 2.1: Use of bleaches (3-5% hypochlorite) in percentage of volume

	FR[1]	ES	PT	IT	UK	IR	NL	BE	DE	CH	SE
plain bleach	60	90	71	88	43	29	28	58	72	100	86
bleach with added surfactants	40	10	29	12	57	71	72	42	28	0	14

(FR=France, ES=Spain, PT=Portugal, IT=Italy, UK=United Kingdom, IR=Ireland, NL=The Netherlands, BE=Belgium, DE=Germany, CH=Switzerland, SE=Nordic Countries)

[1] FR: Marketed as 20 % Diluted / 80 % conc.12,5 %

The mode of use of these products varies across Europe in part related to needs, habits, economical and climatic conditions.

The use habits have in general been evolved on the one hand as a result of consumer experience developed over generations aided by information given by manufacturers of use potential and effectiveness.

An overview of some of the various applications in households of products containing hypochlorite is given in Appendix I.

2.2 Overview of the use pattern of hypochlorite containing products in Europe

Data and information on market size and consumer habit surveys has been provided by industry.

The total market size in various countries around Europe, given in tons of products as sold to the consumer, is given in table 2.2. The data show a division of Europe into several areas:

- Northern countries (Scandinavia and Germany) use only small quantities of household hypochlorite.
- Southern countries (in decreasing order - Spain, France, Italy, Portugal) and the United Kingdom consume large quantities of hypochlorite. In these countries consumption is either increasing slightly or is at least stable.
- Benelux countries lie somewhere between.

Table 2.2: Overview of quantities of products containing hypochlorite used in 1994 (in ktons)

Product containing	FR	ES	PT	IT	UK	IR	NL	BE	DE	CH	SE
3,6 % active Cl_2	350	45						59	19	0,3[1]	6
4-5% active Cl_2		410	95	320	175	7	26				

1 estimate

The widely spread use of products containing hypochlorite in European countries is illustrated through the data presented in Table 2.3. A study of consumer habits showed that in Southern European countries the percentage of households using these products ranges from about 75-95 %. Also in the UK, IR and BE this figure reaches over 80 %. In NL 50 % of the households use a hypochlorite containing product. Much lower use is known to exist in DE. Exact figures are not available for CH and SE, but the use in these countries is expected to be around 30 %.

Table 2.3: Percentage of households using products which contain hypochlorite

FR	ES	PT	IT	UK	IR	NL	BE	DE	CH	SE
77	95	85	76	85	82	50	86	11	[1]	NI

1 Only in French and Italian speaking part of Switzerland
NI No information

The yearly consumption of hypochlorite containing products in households where they are used varies between about 1 to 26 litre. Usage is much higher in the Southern European countries, which might be attributed to the climatic conditions. In a much warmer climate the need and frequency of hygienic cleaning is clearly higher. There may be also other reasons, for instance laundry habits in different countries in terms of the frequency of laundry and the use of high versus low washing temperatures. Table 2.4 gives the data obtained through market research.

Table 2.4: Consumption of products which contain hypochlorite in households which use bleach
(market research data in litres/year/household)

FR	ES	PT	IT	UK	IR	NL	BE	DE	CH	SE
12,5	26,0	15,7	18,6	9,3	7,8	8,0	11,6	2,1	NI	0,8

Market Research has also revealed for which application "bleaches" are being used.

The data in table 2.5 show the percentages of volume used for the two main applications of products containing hypochlorite as:

a. an effective stain remover providing an hygienically clean laundry; and

b. for disinfecting and cleaning household surfaces.

Relatively small volumes are used for other, miscellaneous applications such as vegetable disinfection in France and Spain.

Table 2.5: Percentage of volume used in various applications of products containing hypochlorite (in % of marketed product)

	FR	ES	PT	IT	UK	IR	NL	BE	DE	CH	SE
Laundry	10	30	30	19	8	6	5	5	5		5
Hard Surface (total), of which used in/on the	84	62	70	80	90	88	92	93	93		80
*floor	++	+++	+++	++	+	+	+				
*bathroom	+++	+++	++	++	++	++	++				
*toilet	+++	++	+++	+++	+++	+++	+++	+++			
*kitchen	+	++	++	+	++	++	++				
*fridge	+	+	+	+	+	+	+				
*dustbin	+	+	+	+	+	+	+				
Other uses	6	8		1	2	6	3	2	2		15

NB Where boxes are left blank this means that more precise information is not available. The relative amounts/ratios used within one country are indicated with plus-signs, which should only be read in a vertical direction.

2.2.1 Variation between laundry use and surface cleaning

Thirty years ago, hypochlorite was mainly used for laundry bleaching and rarely for cleaning of surfaces for hygienic reasons. However, since then domestic housekeeping practices have evolved considerably:

- household laundry is not just white, but also coloured;
- cotton is often mixed with synthetic fibres;
- clothes are washed more often and are therefore less stained when being washed.

- many disposable products have made their appearance: baby nappies (diapers), paper handkerchiefs and napkins, intimate protection, disposable tablecloths.

For the last fifteen years, cleaning and disinfection uses on hard surfaces (e.g. floors, walls, sanitary installations, work surfaces) have accounted for over 80% and even up to 90% of the use of products containing hypochlorite in Europe. Only Spain and Portugal still use 30% for laundry.

2.2.2 Laundry

Laundry use of products containing hypochlorite is relatively high in Spain, Portugal and Italy, where washing machines are mostly equipped with a special bleach dispenser. Hypochlorite bleach is added to the washing machine during the rinsing cycle, after the main wash with detergent. Hypochlorite is also commonly used as a pre-treatment, especially with white or light coloured laundry (e.g. towels, underwear, sheets). The recommended dosages of hypochlorite bleach vary from country to country and they are strongly dependent on specific washing conditions (e.g. amount of water used, availability of bleach dispenser in the washing machine, washing temperature).

2.2.3 Hard surfaces

It is very difficult to quantify precisely the volumes of products containing hypochlorite, which are being used for the cleaning of the various hard surfaces. The number of plus-signs in table 2.5 indicates the relative volumes of products used on the various types of hard surfaces.

2.2.4 Disinfection

Toilet disinfection/cleaning is the predominant application of products containing hypochlorite in all countries. Hypochlorite containing products are also used very frequently in bathrooms. Floor disinfection is more prominent in Southern European countries with tiled floors. An obvious area where disinfection is applied is the kitchen with the fridge as a focal point of attention (other examples are kitchen surfaces and the dustbin).

Hypochlorite is effective against all types of pathogens and is commonly and widely used in households for all types of disinfection, particularly to prevent (transmission of) diseases (e.g. 'athlete's food' fungus, food poisoning from contamination of food by dirty kitchen surfaces and the spread of pathogens through baby feeding utensils).

2.2.5 Method of use

Products containing hypochlorite can be used either undiluted or diluted. Table 2.6 shows the percentage of use of undiluted and diluted products in France, the Netherlands and the UK.

Table 2.6: Percentage of use of undiluted and diluted products

	FR	NL	UK
Undiluted, directly onto surface	18	32	31
Undiluted, onto cleaning equipment	15	2	23
Diluted in water	67	66	38

III. OVERVIEW OF EXISTING (AND PLANNED) REGULATIONS, AGREEMENTS AND ACTIVITIES ALREADY CARRIED OUT BY INDUSTRY

This overview is confined to measures, agreements and activities which are related to domestic and consumer use.

3.1 On the European Community level

3.1.1 EC Directives concerning dangerous substances and preparations

According to the Dangerous Substances Directive 67/548/EEC and to the Preparations Directive 88/379/EEC, sodium hypochlorite sold to the general public is registered and classified as in Table 3.1.

Table 3.1 European Community legislation with respect to registration and classification of products containing hypochlorite

	Products containing hypochlorite [1]	
	above 10 % active chlorine (concentrated products)	between 5 and 10 % active chlorine
symbol	C (corrosive)	Xi (irritant)
risk phrase	R 31 (contact with acids liberates toxic gas) R 34 (causes burns)	R 31 (contacts with acids liberates toxic gas) R 36/38 (irritating to eyes and skin)
safety phrase	S 1/2 (keep locked up and out of reach of children) S 28 (after contact with skin, wash immediately with plenty of water) S 45 (in case of accident or if you feel unwell, seek medical advice immediately (show the label where possible) S 50 (do not mix with acids)	S 1/2 (keep locked up and out of reach of children) S 45 (in case of accident or if you feel unwell, seek medical advice immediately (show the label where possible) S 50 (do not mix with acids)
general phrase	Warning! Do not use together with other products. May release dangerous gases (chlorine)	Warning! Do not use together with other products. May release dangerous gases (chlorine)

1 Products containing hypochlorite between 1 and 5 % active chlorine have no symbol, risk or safety phrase. The general phrase for these products is "Warning! Do not use together with other products. May release dangerous gases (chlorine)".

Products containing hypochlorite below 1 % active chlorine need no symbol, risk, safety or general phrases.

The classification of sodium hypochlorite as a substance as far as the environment is concerned has not yet been established by the European Commission. Probably the Italian rapporteur on the EU risk assessment of hypochlorite (cf. § 3.1.3) will make a proposal whether or not hypochlorite should be classified as "dangerous for the environment". Such a proposal will be worked out by the European Commission Working Group on the classification and labelling of dangerous substances.

3.1.2 Labelling of ingredients in detergents and cleaning products

According to the European Commission Recommendation for the Labelling of Detergents and Cleaning Products from September 13, 1989 (89/542/EEC), all hypochlorite solutions above 0,2 % must indicate the presence of chlorine based agents, and indicate the level as being below 5 %, or between 5 and 15 %.

Safety data sheets for preparations containing 12,5 %, 5 % and 3,6 % active chlorine are available to users.

3.1.3 Risk Assessment

Sodium hypochlorite is on the second priority list (published on 28 September 1995 in the Official Journal of the European Communities) within the framework of the EC regulation 793/93 drawn up by the Council 29/03/1993, which lays down the principles of human and environmental risk assessment concerning existing chemicals. Italy is the EU member state in charge of producing this Risk Assessment.

Sodium hypochlorite is therefore currently being assessed at the EC level. The first preliminary results of this assessment have become available at the beginning of 1998.

3.1.4 Proposal for a European Community Directive on biocidal products

The Council and the European Parliament are at present in the course of discussions about a proposal for a Council Directive (93/C239/03) addressing all biocidal products including disinfectants.

Being a disinfectant, sodium hypochlorite will fall under this proposed Directive. In order to list sodium hypochlorite in Annex I to this proposed Directive, which addresses authorised biocide substances, a fully documented dossier on sodium hypochlorite is necessary, including its human and environmental effects as well as proof of its efficacy.

In Annex V of this proposed Directive it is indicated that disinfectants and general biocidal products exclude cleaning products that are not intended to have a biocidal effect, including washing liquids, powders and similar products.

3.2 Activities at the national level

National regulations concerning products containing hypochlorite exist in a few European countries, such as France and Spain. They concern human safety, and also establish the minimal concentrations of sodium hypochlorite necessary in order to guarantee the effectiveness of its use in commercialised products.

French regulations require a minimum concentration of 3,5 % active chlorine for the term "Eau de Javel" and 12,5 % for the term "Eau de Javel concentrée" to be used. Moreover, a voluntary agreement backed by administration limits the level of free alkalinity expressed as sodium hydroxide to 1,5 % for consumer safety.

For the term "Lejia" to be used, Spanish regulations provide for concentration of between 3,5 - 5,5 % active chlorine with the level of sodium hydroxide limited to 1,2 %. Concentrated products contain between 5,5 and 8,8 % active chlorine with the level of total alkalinity expressed as sodium hydroxide limited to 2,4 %.

In Germany, voluntary agreements with industry ensure better user safety (e.g. products available to the general public have a limited level of 5 % active chlorine and must also contain an alkaline reserve in order to reduce the risk of chlorine emission in the case of contact with an acid product).

In Sweden, dishwasher products may not contain any sodium hypochlorite at all.

Table 3.2 gives an overview of the recommended dosages of various hypochlorite products as indicated on the packages in different countries. Table 3.3 gives, on the basis of the data given in table 3.2, the resulting working strength of the products.

Table 3.2: Recommended dosage for dilution of products containing hypochlorite (in ml of product per volume water)

key to information in cells:

	a
b	c

a: amount of water (in litres) where the recommended dosage should be put in
b: minimum recommended dosage hypochlorite-product in ml
c: maximum recommended dosage hypochlorite-product in ml

Country Product Strength (in % hypochlorite)		FR 3,6	ES 4,5	PT 4,9	IT 4,9	UK 4,5	NL 4,5	BE 3,6	DE 3,6	SE 3,6
Laundry	Washing-machine	15 225 300	15 75	20 100 225	20 100 225			15 50 300		
	Hand-wash	10 37 112	20 100	5 25 100	5 50 150	1 15	5 6 25	10 100	10 50	10 75
Hard Surface	Floor	10 75 150	10 100 200	5 200	5 100 500		5 13	10 150	10 60	
	Bathroom	10 75 150	5 200	5 200	5 100 500			 150 300	5 75	1 30
	Toilet Bowl	2 150 225				squirt	squirt	2 150 300	 250	 50
	Sink						5 13	 150 300		
	Kitchen surfaces	10 75 150	5 50	5 100	5 100 500		5 13	5 150		
	Fridge		1 50				5 13	5 150		
	Dustbin	1 300					5 100	1 75 150		

Table 3.3 Working strength (ppm)

working strength = ((product strength) * (dosage)) / (water volume)

product strength:	values given in first row of tables 3.2 and 3.3
dosage:	value for minimum or maximum recommended dosage of hypochlorite-product in ml as given in table 3.2
water volume:	values as given in table 3.2

key to information in cells:

	a
b	c

a: indication whether product should be used undiluted

b: minimum working strength

c: maximum working strength

Country Product Strength (in % hypochlorite)		FR 3,6	ES 4,5	PT 4,9	IT 4,9	UK 4,5	NL 4,5	BE 3,6	DE 3,6	SE 3,6
Laundry	Washing-machine	532 706	224	244 545	244 545			120 706		
	Hand-wash	133 399	224	244 961	485 1427	665	54 224	356	179	268
Hard Surface	Floor	268 532	446 882	1885	961 4455		117	532	215	
	Bathroom	268 532	1731	1885	961 4455			undiluted 36000	532	1049
	Toilet Bowl	2512 3640				undiluted 45000	undiluted 45000	2512 4696	undiluted 36000	undiluted 36000
	Sink						117	undiluted 36000		
	Kitchen surfaces	268 532	446	961	961 4455		117	1049		
	Fridge	1714					117	1049		
	Dustbin	8308					882	2512 4696		

IV IDENTIFICATION OF POSSIBLE MEASURES FOR OPTIMISATION AND RESPONSIBLE USE

4.1 Product composition

In general, product formulations are derived from a process where optimisation is sought and taking into consideration aspects such as:

- consumer needs and expectations;
- intended functionality (also claims);
- intended use (for instance undiluted or diluted);
- technical constraints;
- safety (for consumer, environment, substrates);
- product stability;
- legal constraints.

Obviously, the choice of a particular level of an ingredient in a product is also a result of the above mentioned process.

Over the years, the most prevailing level of hypochlorite across various products has been between 3,5 and 4,5 %. A special legal situation is operative in France and Spain (cf. chapter III), where hypochlorite levels in products have been regulated.

Specialist products (containing 0,5-1,5 % hypochlorite) have been developed and marketed for the specific purpose of disinfection and cleaning of surfaces. Until now, the market success of these products has been limited.

In chapter III, an overview is given on dosage recommendations as described on the packages of the various products (table 3.2 and table 3.3). Taking into account this overview and by using expert knowledge, an attempt will be made to formulate functional concentrations/dosages of hypochlorite for the various uses, which will be applicable European wide. Preliminary recommendations will be available in autumn 1996 and will indicate a wide range of concentrations. Further work has to be carried out to narrow this range.

4.2 Responsible use

Measures can be taken at the following three levels to ensure that, for a given application, the use of products containing hypochlorite is being optimised and does not lead to an unnecessary use.

"Where to use" is determined by consumers and can be influenced by information and instructions from manufacturers or independent bodies.

"Frequency of use" is determined by the consumer and is dependent on cultural and social aspects as well as climatic conditions.

"Amount used" is determined by consumer experience based on recommendations made by the manufacturers. These recommendations are made available to consumers either on the label of the product or in dedicated information leaflets.

In France and Spain, the national legislation requires proof of compliance with disinfection efficiency when disinfection claims are being made. In these countries recommended dosages are therefore linked with the (disinfecting) efficiency substantiation.

The methods for testing disinfection effectiveness are not (yet) harmonised in Europe, which is one of the reasons for a certain variability in recommended dosages between countries. Therefore, an investigation into the spread of currently recommended dosages for specific applications and manufacturers has been carried out (cf. § 4.1 and chapter III) in order to establish the technical basis for recommendations and to enhance harmonisation across Europe.

Specific examples of possible recommendations concerning the responsible use of products containing hypochlorite are:

a. bleach should be used with water at room temperature;

b. bleach should not be mixed with other products. Mixing with acids may form hazardous gases such as chlorine. Mixing with other products may also severely reduce the efficacy of bleach;

c. for optimal results, the recommended use dosage should be carefully followed, e.g.

   (i) toilet bowl: flush the toilet before using the product and flush again, after x minutes (x=contact-time should be precisely stated);

   (ii) kitchen working surfaces: before the application, remove chunks of food from counters and sinks;

   (iii) laundry use: a contact-time should be precisely stated. Moreover, laundry should already be pre-washed before using bleach.

Throughout Europe a number of hygiene-codes have been (and are being) developed to control food safety in different industrial branches. These codes have a formalised status based on EC-Directive 93/43. To complete the chain of food safety, and additional to these industry-codes, the Ministry of Health in the Netherlands, in co-operation with other interested parties, has started a project to develop a hygiene-code for private households.

The aim of this project is to develop before end of 1998 a technical document containing an inventory of risks connected to processes/systems in households and outlining the necessary measures to maintain a responsible hygienic care.
The project comprises three working groups on:

- safety of food;
- personal and sanitary hygiene;
- plague and domestic animals and the indoor environment.

These groups will also discuss whether chemical disinfection in households is needed, and if so, whether it can be made functional through proper education and without causing environmental risks.

4.3 Alternatives for products containing hypochlorite

At present, there are no alternative chemicals (or combinations of chemicals), which deliver an equivalent result of simultaneous disinfection, cleaning, bleaching and deodorisation at similar levels of efficiency and (low) costs as products formulated with hypochlorite. This functionality is derived from the strong oxidative power of the hypochlorite molecule.

For certain specific functionalities/applications, alternative technologies are available, which have nearly the efficiency of hypochlorite based products. Products formulated with hydrogen peroxide are nearly as effective with respect to bleaching and deodorisation, but these products are inferior with respect to disinfection efficiency.

The table in Appendix II lists examples for the various functionalities to indicate the relative effectiveness of a number of ingredient technologies compared to hypochlorite.

More investigations are needed on the comparison between hypochlorite and possible alternatives in order to obtain thorough information on technical aspects and environmental impact. The alternative of using no product at all (because there is no need to do so) should also taken into account.

To this end, attention should be paid for example to the application of bleach to disinfect laundry at temperatures below 45°C in comparison to the alternatives of washing at higher temperatures (more energy spending) and/or longer washing times and/or use of more detergents and/or higher frequency of washing.

More information on the need for disinfection of various objects/surfaces and the disinfection efficiency of hypochlorite will be available when the updated document 'Benefits and Safety Aspects of Hypochlorite' will be published by the European Soap and Detergent Industry (AISE).

A first attempt to deal more thoroughly with possible alternatives will be made in the Netherlands. The table in Appendix II will be extended with more products and with indicative information on environmental impact, special aspects of application and other information that is valuable to determine alternatives.

V IDENTIFICATION OF SOCIAL AND ECONOMIC ASPECTS

There is not sufficient information on alternative products and technologies for hypochlorite with respect to different applications. As a result, it has been impossible to compare hypochlorite on socio-economic aspects with other alternatives.

5.1 Hypochlorite producers

Hypochlorite bleaches are generally produced in high volumes at relatively low costs. However, in some countries, thicker, often perfumed, premium-priced products have a major share of the market, especially in terms of value. Surface cleaner products containing modest amounts of hypochlorite are a recent, but growing innovation. Colgate-Palmolive, Henkel, Procter & Gamble and Unilever are among the largest multinational companies manufacturing hypochlorite-products in the EU. These companies produce bleaches in various European countries. Table 5.1 shows the number of producers in different member states of the European Union. The data provided in this table are data which were compiled from the "Kompass On-line" database, which contains more detailed information on some companies than on others. For this reason, the total number of companies for each country is only an indicative value, which:

a. may not include all actual producers in each country (e.g. the number of hypochlorite manufactures in Spain may well surpass 500, according to the Spanish National Association on Bleaches);

b. does not match the sum of the other columns, which should be interpreted independently.

Table 5.1: Numbers of European producers of products containing hypochlorite

country	total	size						Number of exporters
		turnover (1000 ECU's)			number of employees			
		0-625	625-6,250	>6,250	0-50	51-250	>250	
IT	136	4	29	50	77	39	19	111
FR	66	5	27	17	44	7	5	49
ES	54	-	-	-	29	5	1	20
UK	47	1	10	9	25	12	4	24
BE	36	0	8	8	27	5	2	26
DE	36	0	10	23	16	12	5	29
SWE	33	4	19	8	28	2	3	13
NL	20	-	-	-	15	3	2	18
DEN	16	2	1	6	7	6	1	9
LUX	1	-	-	-	1	0	0	0

Source: Kompass on-line database

With regard to the number of exporters given in table 5.1, consultation with industry indicates that this number relates almost completely to the export of hypochlorite products for industrial use. High volume, low profit household products are hardly exported because of the costs of transportation. It is generally accepted within industry that it is not effective to transport bleach across distances greater than 500-700 kilometres.

According to an abstract from the *Chemical Economics Handbook,* the total combined market value of sodium, calcium and lithium hypochlorite in the US, Europe and Japan for 1996 was ECU 2,6 billion (2,1 billion US$), with sodium hypochlorite being the dominant compound. Growth is expected to continue at an average of 1-2 % per year during the next few years. The French bleach association reports that the consumer goods market is very stable, with no important variation during the last 30 years (and none forecasted in the future*)*. The market for bleach in the Netherlands has also proven to be very stable.

5.2 Domestic hypochlorite users

Hypochlorite-based products for households use fall into two general categories:

a. general surface cleaning and disinfection;

b. laundry cleaning.

5.2.1 General surface cleaning and disinfection

Sodium hypochlorite has a long history of use in the home for cleaning and as a surface disinfectant agent. A significant number of pathogenic micro-organisms can be found in the home, in particular in kitchens and bathrooms. Sodium-hypochlorite is an effective biocidal product, with a non-selective ability to kill persistent microbes

(microbes do not show immune adaptation to hypochlorite). Sodium hypochlorite can contribute to improved hygiene in developing countries. In the Netherlands a survey has been started to investigate, *inter alia*, the exact role of hypochlorite in the hygiene of households. The results of this project "Hygiene in Households" can be expected at the end of 1998.

5.2.2 Laundry cleaning

As stated in chapter II, the application of hypochlorite in laundry is relatively high in Spain, Portugal and Italy, where washing machines are mostly equipped with a special bleach dispenser. In other countries like France, the UK, Denmark and the Nordic countries, the usage of hypochlorite in laundry is only about 5 to 10 % of the total domestic consumption. The use of bleach in laundry has several benefits. It provides the possibility of using lower washing temperatures and less detergent. This results in less use of raw materials and energy, which reduces the environmental impact. A disadvantage is that by using hypochlorite for washing, clothes can wear out quicker.

Due to the widespread use of the product, bleaches are involved in under 6 % of accidents reported to poison control centres and represent 10-23 % of accidents involving household products.

The most common accident by intentional misuse is ingestion of small quantities of the product, which accounts for 50-80 % of all accidents in Europe involving hypochlorite. A considerable portion of these accidents involve children between the ages of one and three. Studies monitoring accidental bleach ingestion show virtually no long-term health effects.

Inhalation is the second most common route of exposure, generally accounting for 15-30 % of accidents with hypochlorite. When misused, hypochlorite can react with other household cleaning products, in particular with acidic products and ammonia. The gases liberated (chlorine or chloramines) in these incidents are very irritant and warn the user immediately, significantly reducing the risk of prolonged contact. Patients with pre-existing asthmatic conditions appear to be at a higher risk of serious health consequences.

Several studies show that in most cases of accidental inhalation of toxic gases resulting from mixture of hypochlorite and other cleaners, the level of exposure is too low to cause any tissue damage. Any adverse health effects are usually mild irritations with complete recovery within six hours without medical treatment.

The third and fourth most common routes of exposure involve irritation of skin and eye tissue. In a study of irritation to eye tissue, it has been shown that 98 % of all patients recovered completely within one day. The remaining 2 % also recovered completely, within a span of two to 60 days.

The above data show that the risk to human health posed by hypochlorite bleaches appears to be relatively low. Although it is clear that ingestion and mixing these products with other cleaners can result in fatalities, such incidents are extremely rare. Non-fatal accidents tend to have very limited impact in terms of severity and duration of symptoms.

VI CONCLUSIONS

A comprehensive overview of the use of hypochlorite in households has been carried out.

From the information given in the various chapters, it is concluded that the formulation of best environmental practices (BEP) on hypochlorite use in households cannot be regarded as a high priority for OSPAR with respect to the protection of the marine environment. For the time being, the OSPAR Working Group on Diffuse Sources will give further consideration to the need of an OSPAR BEP for the use of hypochlorite use in 1998, taking into account, *inter alia*, developments with respect to this issue in the EU.

The information in this background document could be valuable with regard to the transfer of expertise to other international fora for which the formulation of a BEP is more appropriate (e.g. for health and safety considerations).

Chapter III concerns existing regulation/agreements and chapter IV gives an overview of possible technical measures. Possible future work on a BEP (including technical measures), might take into account the information of chapters II-VI.

Suggested possible measures and instruments include:

a. manufacturers shall propose precise directions for the use of all hypochlorite preparations on labels or on separate leaflets;

b. a sentence shall be added on labels and leaflets, recommending to follow strictly all use concentrations and not to use too much of the product, such as: "*Follow carefully the recommended use concentrations*".

c. where possible, press information explaining how to handle and how to use safely hypochlorite preparations shall be developed.

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APPENDIX I

Application of hypochlorite products in the home

Location/ Tasks	**Disinfection**	**Cleaning**	**Bleaching**	**Deodorisation**
Kitchen	Objects involved in household in food preparation. Food storage areas and fridges. Floors. Waste bins. Cleaning implements (cloths, sponges).	All surfaces that contact food and hands. Fridges. Waste bins. Vegetable storage bins. Floors.	Beverage stain removal.	Waste bins, drains. Fridge interiors. Vegetable storage bins.
Bathroom/ toilet	WC bowls inside and outside. Baths, showers and fittings. Taps, handles. Floors. Areas with fungal growth.	WC bowls inside and out. Walls, baths, showers and fittings. Rubber bath maths, shower curtains. Grouting, seals.	Fungal stain.	Urine, faecal odours. Showers, waste overflow and drains.
Laundry	All textiles suspect of pathogen contamination.	Bedlinen, towels, underwear. Food spillage. Restoring whiteness to clothes washed at low temperature.	Removal of stains from table linen, tea towels.	Removing musty smell from damp stored linen.
Others	Pet areas, equipment. Areas contaminated by spillage (sputum, vomit, faeces). Areas infested with insects. Baby's toys, highchair, potties etc. Feeding utensils.	Flower vases, fish tanks, garden furniture. Hard floors in halls, kitchens, toilets. Spillage, vomit, faeces. Baby's toys, cots and feeding utensils.		Pet cages, baskets. Removing odour of vomit, faeces, urine.

APPENDIX II

Comparison of effectiveness of example ingredient technology

Ingredient	Disinfection	Cleaning	Bleaching	Deodorisation
Hypochlorite	+++	++	+++	+++
Hypo/ Surfactant	+++	+++	+++	+++
Alkali/ Surfactant	o	++	o	+
Quaternary	++	+	o	+
Hydrogen peroxide	++	+	++	++
Soap	o	+++	o	o
Soap/Phenols	+	++	o	++

OSPAR Commission
1999

Section II

Use of Sodium Hypochlorite as a Desinfectant in Swimming Pools

Contents

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I INTRODUCTION

1.1 Conclusions

The first step in the development of a description of Best Environmental Practices (BEP) is the preparation of a background document, which comprises all relevant information for a discussion of the need for, and the possible content of, a BEP measure concerning the use of sodium hypochlorite as a disinfectant in swimming pools. With this document, this first step has been finalised. Based on the information provided, OSPAR agreed that further work on a BEP measure for hypochlorite in swimming pools should not be considered, unless the need for such a measure would be indicated by the dynamic selection and prioritisation mechanisms of hazardous substances, which will be carried out within OSPAR.

It should be noted that within the framework of the EU Directive 793/93, it was decided to make a study of the assessment of risks associated with the use of sodium hypochlorite (second priority list dated 28/09/1995 published in the Official Journal of the Community). However, OSPAR agreed to publish this document before this European Community risk assessment study was finalised.

1.2 General Introduction to Hypochlorite in Swimming Pools

Maintaining good sanitary conditions in swimming pools is a public health imperative, which assumes the use of appropriate disinfectants for guaranteeing the environment's bacteriostatic properties.

Any products likely to be used should, in addition to maximum effectiveness of desinfection, present a remnant effect and should be easy to use.

For these reasons, mainly halogenated compounds (in particular sodium hypochlorite) are being used as disinfectants in swimming pools.

The sodium hypochlorite is a highly reactive molecule. In the presence of organic compounds (which are mostly introduced in swimming pools by swimmers), it inevitably forms by-products which are likely to find their way into the marine environment of the North-East Atlantic.

A sufficient (even if not thorough) qualitative and quantitative knowledge of these by-products, how they are formed and any impact they might have on the marine environment, is therefore desirable.

On the basis of this knowledge, Best Environmental Practices (BEP) could then be established, which would:

a. guarantee the objective of public health in swimming pools;

b. ensure the optimal use and consumption of sodium hypochlorite for this purpose; and in doing so

c. minimise discharges of by-products into the marine environment.

However, as already indicated, such action is not on the agenda of OSPAR for the time being.

This document, presented jointly by the three leading countries, Spain, France and the Netherlands, summarises the information gathered in the following areas:

- functionality and main uses of sodium hypochlorite;
- synthesis of existing statutory situations relative to the operation of swimming pools;
- socio-economic aspects relative to swimming pools and their operation;
- origins of by-products and an assessment of their quantities;
- environmental effects;
- conclusions and recommendations of appropriate measures to optimise the use and consumption of sodium hypochlorite.

II FUNCTIONALITY AND MAIN USES OF SODIUM HYPOCHLORITE

2.1 Identification of hypochlorite applications

Sodium hypochlorite (chemical formula NaOCl) was discovered at the end of the 18th century.

Originally used for the bleaching of textiles, many other uses were developed taking into account the remarkable chemical properties of sodium hypochlorite and, as a result of these properties, its ability to destroy pathogens.

Though not exhaustive, the following list of applications is an indication of the many uses of this simple and economically very affordable molecule.

2.1.1 Uses based on oxidising properties

- Chemical synthesis;
- Pharmaceutical synthesis (Vitamin C using the Hoffman process);
- Textile industry;
- Paper industry;
- Industrial and domestic wastewater treatment;
- Refrigeration water treatment (algicide and prevention of amoeba proliferation).

2.1.2 Uses based on disinfectant properties

- Hospital hygiene (prevention of diseases);
- Drinking water distribution (microbiological protection within distribution networks);
- Disinfection in the food-processing industries;
- Hygiene in mass catering establishments;
- Domestic hygiene (bed linen, floors, toilets etc.);
- Sanitary protection in public swimming pools.

The ubiquitous presence of pathogens has always been a major, global public health problem. This concern has even increased considerably in recent years when realising that colonies of pathogens have developed resistance to known antibiotics.

Even in the so-called "developed" countries, infectious diseases are responsible for the majority of deaths, up to 50 % in some countries. Even where the risks of such mortality are low, the treatment of infectious diseases causes very high costs, which are disproportionate to the costs of prevention guaranteed by good hygiene rules.

Prevention by disinfection is therefore a necessity from both the sanitary and the socio-economic points of view.

2.2 Use in swimming pools

The risks associated with using (public) swimming pools are of a biological nature, resulting mainly from the presence of pathogens in the water. However, it should not be forgotten that certain pathogens are also present in the air and on the floor.

Normally, four categories of micro-organisms present in swimming pool water can be distinguished:

- protozoa (including certain amoebas);
- fungi (yeast, mould);
- bacteria (streptococcus, staphylococcus etc.);
- viruses (hepatitis A, verrucas etc.).

Protozoa consist of two categories:

a. sacrophite, which live on decomposing vegetable or animal matter (*paramecia*); and

b. parasites which live at the expense of other living organisms and cause diseases (*amoebas*).

Fungi are responsible for superficial skin diseases such as mycoses, which are often localised in the foot area.

Bacteria have quite a long lifespan and develop very rapidly as soon as they encounter favourable conditions. Whilst many bacteria are not pathogenic (some are even vital to our life), others such as *Streptococcus*, *Staphylococcus* or *Bacterium colic* can cause serious pathologies.

Viruses which may be present in swimming pool water can cause pathologies such as meningitis, poliomyelitis or viral hepatitis.

Whilst various preventive measures may attenuate the risks due to pathogens, permanent and persistent action is essential.

The purpose of disinfection therefore has to be twicefold:

- disinfecting water, destroying germs in the process;
- retaining the disinfection properties to eliminate pathogenic micro-organisms as they are introduced into the pool.

Sodium hypochlorite appears as an ingredient in nearly all products which meet these requirements (cf. legal situations).

Without going into too much detail as regards the various protozoa, fungi, bacteria and viruses which can be destroyed by sodium hypochlorite, it should be noted that its effectiveness has been demonstrated on:

- *Salmonella choleraesuis*;
- *Staphylococcus aureus*;
- polioviruses (hydrophilic);
- *Herpes simplex* (lipophilic);
- *Candida albicans*;
- *Trichophyton mentagrophytes*;
- *Bacillus cereus*.

Sodium hypochlorite acts extremely quickly on germs. In parallel, an oxidising action is exerted on the organic matter introduced into the pool, with the formation of by-products.

Thus the "chlorine" introduced by sodium hypochlorite will be found in the pool in various forms:

a. "consumed" chlorine in the chloride state;

b. "combined" chlorine in the form of chloramines and chlorinated organic matter (i.e. by-products). It should be noted that the chloramines themselves have a disinfectant power;

c. "free" chlorine including:
   (i) active chlorine in the form of hypochloric acid;
   (ii) potential chlorine in the form of hypochlorite ions.

Measuring the "free" chlorine gives an indication of the disinfection potential available in the pool, whereas measuring the "combined" chlorine indicates the quantity of substances likely to be transformed into irritants.

It is therefore important to introduce a dose of hypochlorite which will produce sufficient free chlorine to provide good disinfection without exceeding the levels which would create discomfort.

The ease of dosing hypochlorite satisfies this concern. Moreover, sodium hypochlorite is widely available and very low in terms of cost.

Sodium hypochlorite therefore presents a set of characteristics which perfectly match the disinfection requirement in public swimming pools.

It should be noted that gaseous chlorine is also frequently used as a disinfectant, particularly in large public swimming pools. Its action, and the by-products it produces, are comparable in all respects with those of sodium hypochlorite.

III EXPLOITATION PRACTICES AT SWIMMING POOLS

Good exploitation practices at swimming pools contribute directly or indirectly to improved sanitary conditions and allow to optimise the use and consumption of disinfectant agents.

Depending on the age and general features of each swimming pool, various water treatment systems and water recirculation arrangements are being used. Nevertheless, a few basic rules are valid and are being applied in the management and exploitation of all swimming pool equipment, regardless of the particular treatment combination used. These rules relate to:

a. the follow up of the function and performance of the installation;
b. the monitoring of physico-chemical water parameters.

3.1 Installation performances follow up

Each element of the water circuit has to be checked on a regular basis by means of reporting of measurements, in particular as regards cleanliness of buffer tanks, pressure drop in the pipes (incrustation), water recirculation flow and fresh water make up.

It is important that each swimming pool operator record these observed data in writing.

The function of the filters and the injection of reactants are the two key elements which have to be carefully monitored.

3.1.1 Filters

Water filtration is a basic operation in the treatment of swimming pool water.

If properly conducted, water filtration results in an efficient elimination of insoluble organic matter. Consequently, it allows for a reduction in the quantity of disinfectant additives to be used to guarantee a good biological quality of the water in the basins. A part of soluble organic matter can also be eliminated by filtration through absorption and biodegradation in carbon or in hydro anthracite filters.

Filters can be designed by using various principles such as sand filtering media, single layer or double layer "hydroanthracite" media with slow or fast water circulation, diatom filtering media. Whatever the filtration process, a few basic rules must be applied:

a. the system should automatically switch filters when the used filter has become saturated. This filter switch can be triggered following a time sequence or on detection of an excessive drop in pressure or of an insufficient water flow;

b. execution of an unclogging and regeneration cyclic sequence after the filter switch, including a maturation procedure before reuse of the filter in the filtering process.

Continuous filtration 24 hours a day is required. (During the night when the swimming pool is not used the water circulation through the filter can be reduced).

3.1.2 Reactants

A satisfactory performance of a sand filter (the most commonly used filter type) is based on the injection of a flocculating agent which helps to trap colloidal substances. Flocculate dosage is of the utmost importance. A deficit in flocculate results in insufficient filtration efficiency, whereas an excess of flocculate results in secondary flocculation effects occurring in the basin and leading to turgidity. Water pH strongly influences the flocculation efficiency (e.g. optimal pH range is 6,9 to 7,2 for aluminium sulphate). As pH adjustment is also critical for disinfecting efficiency, the correct adjustment of that parameter has to be carefully monitored.

In order to prevent incrustation of hypochlorite injection nozzles, acid injection for pH adjustment is very often placed before hypochlorite injection very near to the basin. As swimmer density varies in the basin, the pH value can vary in over a wide range at the flocculate injection point and in the filters.

In the most efficient installations, acid injection is placed as far upstream as possible in the water recirculation circuit, preferably in the buffer tank which holds the overflow of the basin.

Fine tuning of the flow of acidifying agents is the key element for efficient flocculation and, consequently, for good filtering operation.

IV REVIEW OF REGULATIONS GOVERNING THE USE OF HYPOCHLORITE IN SWIMMING POOLS

Whilst some elements of the various national (or sometimes regional) legislation differ, they all have a single objective:

4.1 Guaranteeing the sanitary quality of the water in public swimming pools

4.1.1 Disinfectants

The following products are listed as possible disinfectants:

a. Chlorinated products:

- gaseous chlorine. Its use is widespread but is usually limited to large pools which can implement safety procedures governing the handling of the gas bottles;
- sodium hypochlorite;
- calcium hypochlorite;
- chloroisocyanurated derivatives (e.g. trichloroisocyanuric acid);
- sodium dichloroisocyanurate.

All these products are used particularly in open-air swimming pools as they offer better stability to the sun's ultra-violet rays. The chlorinated products chlorine, sodium and calcium hypochlorite, and chloroisocyanuric derivatives, are used in all countries in most (if not all) cases.

b. Biguanide polyhexamethylene

This product is sometimes used, but requires careful handling. The temporary approval of the use of this product has not been renewed in one country.

c. Ozone

Ozone has good disinfectant properties, but it is not persistent enough to guarantee that disinfection properties of the water are retained. In countries where it is not prohibited, ozone can only be used if a secondary disinfectant treatment is also applied.

d. Brominated derivatives

oxygenated water (with additional treatment)

copper/silver electrolytic processes (for private swimming pools)

The use of these products are authorised only in some countries.

Having recommended suitable products to achieve good disinfection, the legislation then defines the conditions under which they are to be used.

The legislation covers all (or some) of the items below, which are all likely to produce good disinfection and optimise the use and consumption of disinfecting agents.

a. Water used to top up the pool

   Only drinking water from the public supply system can be used for this purpose. The use of water from any other source must be authorised. It must in all cases meet the criteria applicable to drinking water;

b. Quantity of top-up water

   The quantity of top-up water is usually regulated at a minimum of 30 litres per swimmer;

c. Filtration

   Filtration is compulsory. The filter dimensions depend on the rate at which the water is recirculated. Several types of filtration are possible (slow, fast) and several filtration media are authorised (sand, diatoms etc.). It is essential to exercise supervision over the clogging of filters;

d. Recirculation rate

   The recirculation rate is usually fixed according to the volume of water in the pool;

e. Method of circulation of water in pools;

f. Level of use

   Some legislation defines a maximum number of swimmers according to the surface area of the pool;

h. Emptying of pools

   Complete and regular emptying of pools is sometimes called for, for example twice a year.

The legislation then set various parameters for controlling the quality of the pool water. Three parameters are systematically stipulated:

a. pH-value

   The chemical equilibrium between the various forms of "chlorine" in the water are governed by the pH. It therefore follows that the disinfecting action itself depends on the actual pH. The higher the pH, the less effective the action, and the more chlorine is required. The lower the pH, the more effective the action, but problems with corrosion of equipment can occur. The various legislation therefore put forward a pH range which must be complied with, e.g. usually between 7 and 7,6 (between 6,5 and 8,5 as extreme values).

b. "Free" chlorine (i.e. the chlorine available for disinfection purposes)

The legislation is similar in all countries by stipulating ranges with a minimum of 0,4-0,5 mg/l and a maximum of 1,4-2 mg/l. Some legislation refer not to "free" chlorine but to "active" chlorine.

c. "Combined" chlorine (i.e. the proportion of chlorine in the form of chloramines or organohalogenated compounds which have reacted with organic matter)

The values reported by countries range between 0,4 to 1 mg/l.

In addition to these three basic elements which guarantee good disinfection, national legislation sometimes imposes other control parameters, including:

- bicarbonate level;
- oxidisability (potassium permanganate test);
- content of chloride;
- urea;
- colouring agents;
- ammonia;
- temperature;
- odour etc.

Finally, legislation imposes regular control of the microbiological quality of the water in the pool, usually in terms of:

- number of germs;
- total coliforms and faecal coliforms;
- pathogenic staphylococci.

Although certain statutory aspects are likely to contribute to prevent the introduction of pathogens (sanitary installations, compulsory foot baths), it appears that no legal obligations apply to swimmers' personal hygiene.

As regards the environmental impact of swimming pool water, the legislation requires that this water be discharged into the natural environment (with the possibility of a dispensation being allowed for) or into the public sewer networks.

Alongside these statutory obligations which are aimed only at guaranteeing the microbiological quality of swimming pool water, recommendations also exist with respect to the operation of the pool, including some which are likely to optimise the consumption of disinfectant, such as pH regulation, disinfectant dosage and the coagulation/filtration technique. Techniques are also referred to which are likely to reduce the combined chlorine concentration, such as UV treatment, ozonation, adding activated carbon etc.

These techniques, which are expensive in terms of investment and operating costs, require special technical monitoring and under no circumstances obviate the need to use a disinfecting agent.

Table 1

Main Statutory Requirements Concerning Swimming Pools and the Quality of Swimming Pool Water in France, Spain, Belgium and the Netherlands

	France	**Spain** (proposed values)	**Belgium**	**Netherlands**
Filling water	Public supply or water complying with the sanitary standards governing drinking water			
Daily top-up	30 litres/swimmer/ pool	5% of pool volume	30 litres/swimmer/ pool	30 litres/swimmer/ pool
pH range	6,9 - 7,7	7 - 7,4	7 - 7,6	6,8 - 7,8
Turbidity (NTU)		≤ 0.5 in pools ≤ 0,2 at filter outlet		
Free chlorine (mg/l)	0,4 - 1,4 (active)	0,5 - 2	0,5 - 1,5	0,5 - 1,5 (active)
Combined chlorine (mg/l)	≤ 0,6	≤ 0,4	≤ 1	≤ 1
$OxKMO_4$ (mg/l)	no more than 4 mg/l of top-up water content	≤ 0,3	≤ 5	limit of 6 mg/l + 70 % of background concentration of the daily top up
NO_{3-} (mg/l)		≤ 20		
NH_{4+} (mg/l)		≤ 0,3		
Urea (mg/l)			≤ 2	
Chlorides (mg/l)	≤ 200 mg/l (guide value)			
Colouring agents		≤ 0,5		

V SUBSTITUTES TO THE USE OF SODIUM HYPOCHLORITE

In order to guarantee good hygiene conditions, swimming pool water must be disinfected and display disinfection capabilities. This latter requirement necessitates that the disinfecting agent has a remnant action.

Such necessity justifies the use of sodium hypochlorite or, more generally, of oxidative halogenated compounds.

Potential substitutes to sodium hypochlorite can be classified in 3 categories:

a. intrinsic substitutes, which can be used on their own;
b. substitutes which have to be used in combination with halogenated oxidising compounds;
c. disinfectants which can be used in some cases in public swimming pools depending on national legislation.

5.1 Intrinsic substitutes

5.1.1 Gaseous chlorine

Gaseous chlorine operates in water in a similar way to sodium hypochlorite, and offers the possibility of accurate concentration adjustment.

5.1.2 Sodium dichloroisocyanurate (DCCNa) and potassium dichloroisocyanurate (DCCK)

These compounds disinfect water by releasing hypochloric acid. They furthermore release a stabiliser against UV rays action.

Regular use of DCCNa contributes to a continuous increase of the chlorocyanuric acid concentration in the basin.

As the stabilising action also decreases the chlorine activity, the average free chlorine content has to be maintained at a higher level (in the range of 2 to 4 mg/l according to French legislation).

The rate of reaction occurring between chlorine and organic matter is different to the one observed with chlorine or hypochlorite without the presence of a stabiliser and a lower formation of chloroamines and haloforms is noticed.

Handling is quite easy, but due to the risk of decomposition, the product must be stored in a perfectly dry place and storage conditions must be carefully designed and controlled.

These compounds are mainly used for open air swimming pools.

5.1.3 Bromine

Hypobromic acid is generated during bromine dissolution in water and displays a very high disinfectant activity. An alternative is to generate bromine "in situ".

To be properly effective, a very precise pH adjustment is required, in the range of 7,5 to 8,2. Molecular bromine concentration increases at a pH value below 7,5 and swimmers may suffer from eye irritation. In addition, corrosion of the installation can occur.

As a consequence of storage and handling constraints, in addition to a higher operating cost, bromine is not very frequently used in swimming pools.

5.2 Substances used in combination with oxidative chlorinated compounds

5.2.1 Chlorocyanuric acid

Chlorocyanuric acid is added to the water of open air swimming pools treated with chlorine or sodium hypochlorite in order to stabilise hypochloric acid against action of UV rays. A maximum chlorocyanuric acid concentration has to be respected (in France, 75 mg/l).

5.2.2 Ozone

Ozone is a powerful bactericide as well as an oxidative agent. It can destroy germs but it does not transfer a disinfecting capability to the water.

Ozone has to be produced "in situ" by means of a specific reactor.

Water ozonisation has to be conducted with a minimal ozone concentration and a minimal contact time in order to be efficient (in France required conditions are at least 0,4 mg/l and at least 4 minutes).

Ozone is a toxic gas so that water has to be deozonised before recirculation to the swimming pool basins.

Complementary disinfection by means of an agreed disinfecting agent with remnant action is always required.

The advantage of an ozone pre-treatment is that organic matters are destroyed and therefore the addition of complementary disinfectant agents is reduced.

Nevertheless, due to the size of treatment installations, the very high investment costs and the requirement for intensive ventilation, ozone treatment can only be justified for very large installations.

5.2.3 UV radiation

The exposure of a flow of water in thin layers to UV radiation with a properly selected wavelength, gives a satisfactory water disinfection.

Nevertheless, as with ozone, the nonremanent effect UV radiation treatment makes a complementary disinfecting action necessary.

Such a process can reduce the formation of by-products.

Investments as well as operating costs are rather high.

5.2.4 Activated carbon

Activated carbon in form of powder or in beads has the capability to trap a great proportion of halogenated by-products originating from the disinfection mechanism and therefore allow generally a lower water and disinfecting agent consumption.

A variety of possibilities exist either in the form of dedicated filters (with regular changes of the activated carbon load) or in the form of continuous injections of activated carbon powder in the water recirculation flow with final retention of the powder on a filter.

As the additional investment is rather substantial, a decision to use such a technique has to be subject to a technical/economic evaluation.

5.3 Other products - other processes

"In situ" electrolysis of sodium chloride is quite successful for private or small size swimming pools treatment. This process produces sodium hypochlorite by electrolysing a saline solution and avoids problems of storage of active products.

In the case of larger swimming pools "in situ" chlorination can also be carried out, but the chlorination equipment has to be somewhat oversized in order to cope with peaks in swimming pool attendance. The limited increase in operating costs has to be balanced with the avoidance of potential storage problems.

By-product formation rate is the same as with hypochlorite injection.

Peroxide disinfection is under testing in the CARIBA swimming pool (GORINCHEM - The Netherlands) where the disinfection is carried out with hydrogen peroxide (25 - 50 ppm), stabilised with approx. 10 µg/l silver ions.

Results of this pilot test will be available by 1998.

A derogation for the use of peroxide (instead of hypochloric - acid) was given by the competent authority for the duration of this experiment.

ammonium compounds, brominated derivatives, biguanine hexamethylene chloro-hydrate, copper / silver electrolytic process. The possibility of using these products depends on national legislation.

VI IDENTIFICATION OF POSSIBLE MEASURES FOR OPTIMUM AND RESPONSIBLE USE OF HYPOCHLORITE IN SWIMMING POOLS

Various studies have revealed the following significant facts:

a. swimming pools, especially open-air pools, play an essential social role;

b. it is essential, for reasons of public hygiene, to have disinfecting water;

c. chlorine and sodium hypochlorite act as effective disinfectants at very low economic costs;

d. the use of chlorine and sodium hypochlorite leads inevitably to the formation of halogenated organic by-products, proportionate to the organic matter introduced by swimmers. A part of these halogenated organic by-products find their way into the North-East Atlantic;

e. the study did not reveal any products which are toxic, persistent and liable to bioaccumulate (all at the same time);

f. the objective of reducing the quantity of halogenated organic by-products discharged into the marine environment of the North-East Atlantic, by means of optimising the quantities of disinfectant used, can be achieved without calling into question the quality of disinfection.

It would therefore seem possible, whilst retaining the same level of disinfection to achieve the public health priority objective, to adopt methods of operating public swimming pools which will allow:

a. the use of disinfectant to be optimised;

b. to reduce the amount of disinfectants used;

by means of various types of measures.

A first type of measure would consist of recommending to the responsible parties involved, i.e. operators and supervisory authorities, to adopt practices which would make it possible to reduce the amount of AOX by-product precursors introduced into the swimming pools. These measures might concern:

a. swimmers complying with basic hygiene rules (using the toilets, compulsory showers and foot baths, wearing bathing caps etc.);

b. providing swimming pool operators with training and information concerning the need to impose strict hygiene standards and comply with best practice in the use of disinfectants;

c. examining whether it is appropriate to limit the number of swimmers allowed to use pools at any one time.

A second type of measure would address the definition of operating criteria for swimming pools by the competent bodies in order to limit the formation of by-products without compromising the level of disinfection. Such measures could include:

a. defining a precise optimum pH range and complying with this pH range in all circuits of the pool;

b. fixing minimum and maximum free chlorine levels;

c. fixing and regulating a maximum combined chlorine level in the water;

d. regular injection of re-agents to guarantee constant pH and active chlorine values, thus avoiding momentary overdosages;

e. optimising the location of re-agent injection points;

f. careful monitoring of the coagulation and filtration stages.

In certain special cases, additional technical provisions may be envisaged such as:

a. in high-capacity swimming pools, the beneficial effect of additional physico-chemical treatments might be examined from the point of view of the performance obtained and their economic feasibility;

b. in open-air swimming pools, measures should systematically be taken to prevent the introduction of external organic matter (leaves etc.).

The proper functioning of the various regulations must be checked by regular controls concerning, at the very least:

a. the microbiological quality of water in swimming pools;

b. the values for pH, free chlorine and combined chlorine.

Any provision of such matter would have to be developed in cooperation with all interested parties (with a priority to swimming pools operators) before implementation.

VII SOCIO-ECONOMIC ASPECTS

The contribution of swimming pools to the people's welfare is not disputable.

Public swimming pools, and above all indoor public pools which allow people to go swimming all year round, are therefore an irreplaceable part of our everyday life.

Proper operation of swimming pools involves a certain amount of unavoidable expenditure, which cannot be economised. Indeed, an operator must provide swimmers with instruction, safety (swimming instructors), hygiene and comfort.

Heating the water and air, maintaining good air renewal (and consequently regulating the relative humidity), compliance with operating rules (rate of water renewal, filter cleaning, maintaining good water transparency, emptying the pool) all represent costs which are proportional to the extent to which the pool is used, and cannot be reduced by very much, if at all.

There is also the cost of the water treatment and disinfection reagents.

By way of example, a survey carried out in France of "standard" pool operators (25 m pool, used by between 70 and 90 000 swimmers per year) shows that total costs may reach the order of 3 million French francs as against an income of 500 000 French francs.

70 % of swimming pool users are children, which, to a large extent, use the swimming pool in school parties free of charge.

It is therefore in the economic interest of a swimming pool operator to optimise the consumption of reagents used, including sodium hypochlorite, which is in any case probably the cheapest disinfectant. Furthermore, the use of sodium hypochlorite in swimming pools represents only one thousandth of chlorine production in return for a major contribution to society.

The economic benefit of optimising the use of sodium hypochlorite is therefore an additional factor, which helps to reduce the possible environmental impact of swimming pools.

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Section III

The Origin and Type of Pollutants - Environmental Effects

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I INTRODUCTION

Hypochlorite is a highly reactive chemical which, during and after its application, gives rise to the formation of various types of reaction products which can be emitted into the environment. The nature of the reaction products depends on the reaction conditions of, and the substances involved in, the reaction. Most of the hypochlorite will be rather quickly converted into sodium chloride (salt water) (e.g. Stachel *et al*, 1985; Koczwars *et al*, 1983).

Under normal usage conditions (both in households and in swimming pools) the major reaction mechanism is oxidation of inorganic and organic compounds, resulting in a variety of oxidation products and chloride ions. In the presence of compounds containing nitrogen (N-compounds such as ammonia, amino acids, proteins), nitrogen-chlorination also takes place, leading to the formation of labile N-chlorinated compounds, such as chloroamines. Finally halogenation can also occur, which is the main route to the formation of organohalogen by-products (OBPs). OBPs include a wide diversity of compounds, all of which have one or more chlorine atoms in the molecules. Some OBPs cause hazardous environmental effects whereas other OBPs are judged quite harmless (Expert panel, 1994). As hypochlorite will under normal circumstances not reach the environment, considerable attention is given in this document to OBPs.

Nature itself produces a wide amount and variety of OBPs, mainly due to the abundance of chlorine in the environment and the ease with which chlorine combines with other compounds.

Organohalogens are often quantified as a single group, based on their ability to adsorb to activated charcoal. These organohalogens are defined as AOX (Adsorbable Organic Halogens). As a rule of thumb in domestic use conditions, an overall hypochlorite-to-AOX conversion degree of 1,5 % is often used (Schowanek *et al*, 1996). Other studies show a conversion rate between 0,1 and 6 % for the various domestic applications of bleach (in: Schowanek *et al*., 1996). In swimming pools, various calculations based on laboratory tests show, that less than 1 % (0,75 %) of the chlorine is combined in the form of organochlorinated compounds. A detailed analytical assessment recently carried out on a public swimming pool shows that this level is in fact below the order of 0,5 % (LEGUBE *et al* 1996).

In general, the formation of AOX is enhanced by a neutral pH, by high levels of hypochlorite and a long reaction time.

II IDENTIFICATION AND EFFECTS OF THE INDIVIDUAL REACTION PRODUCTS RESULTING FROM CHLORINATION OF WATER

The conditions used in households seems less advantageous for the formation of OBP than those of many industrial processes. Nevertheless, various individual reaction products of the use of hypochlorite, such as inorganic and organic monochloramines, chloroform, di- and trichloroacetic acids, dichlorinated acids, bromodichloromethane etc have been detected following the non-industrial use of hypochlorite.

According to studies in various swimming pools, OBP compounds represent virtually all the AOX values measured. The unidentified proportion in swimming pools seems to be low, while a large part of the individual OBP constituting the AOX emission of hypochlorite in domestic use remains to be identified. For instance when using hypochlorite for laundry bleaching, only approximately 25 % of the AOX formed could be attributed to individual compounds (Smith, 1994). One explanation for this apparent contradiction might be that the individual compounds formed by hypochlorite used in swimming pools were identified before the emission flows into a sewer-network, while effluents from domestic uses were identified after sewage treatment. In the sewer-network and the sewage treatment plant a lot of complex reactions are initiated, so the results of these two types of analyses cannot be compared.

Few data are available on the AOX concentrations of domestic effluents which are not linked to a sewer network and are instead stored (under anaerobic conditions) in a septic tank. Smith *et al* (1995) report 87-94 % removal of AOX associated with the use of hypochlorite in bleached laundry wash water, when treated in a domestic septic tank system followed by soil leaching. As adsorption was found to be insignificant, it was concluded that AOX was removed by biodegradation or by chemical decomposition.

In the general context of disinfection by the use of hypochlorite, it is expected that a large fraction of AOX will consist of OBPs with high molecular weight e.g. halogenated compounds of proteins and fats. This fraction seems to be lower in the case of swimming pools. Dioxin (also an OBP) is not formed by uses of hypochlorite in household nor in swimming pools (e.g. Rappe *et al*, 1992).

Comparison of the measured or calculated concentrations of the individual identifiable compounds in the effluent of an adequately operating domestic sewage treatment plant with no-effect levels shows, that adverse environmental effects of these identified compounds are not likely (AISE. 1997). The OBPs that remain after treatment in a sewage treatment plant had no effects on fathead minnows and *Ceriodaphnia dubia* after 7 days of continuous exposure to concentrations 10 to 20 times higher than expected in the effluents of a sewage treatment plant before it is diluted in a lake or river. In addition, no bioconcentrable or lipophilic chlorinated organic compounds could be detected in the effluents at a detection limit of 10-100 ng/l using an US Environmental Protection Agency test method (Ong *et al*, 1996). The OBP that remain after prolonged treatment had no effects on *Daphnia magna* after 21 days of continuous exposure to concentrations at least 25 times higher than expected in undiluted effluents.

III EMISSIONS AND EFFECTS OF AOX

A field monitoring program in the city of Parma, Italy, showed, that the domestic use of hypochlorite bleach contributed approximately 30 % of the AOX level in domestic sewage at that site. However, according to a Swedish report, less than about 1 % of the AOX in sewage originates from household uses of hypochlorite (Kemi, 1995). In general, the average AOX concentrations observed in the Parma-study (approximately 135 µg/l AOX/l) fell within the typical range for domestic sewage across Europe (approximately 50 - 250 µg AOX/l) (Schowanek *et al.* , 1996).

The Parma study also revealed that, under the particular conditions of the study site, the use of hypochlorite in households contributed 37 µg AOX/l. An other important source was tap water (15 µg AOX/l). AOX-levels in tap water vary widely around Europe. Most of these variations can be attributed to the raw water source and the treatment technology used. AOX-levels can range up to a few hundred µg/l, especially where the raw water is reused from surface waters. Accordingly, the proportion of AOX in domestic sewage accounted for by the domestic use of bleach also varies widely.

A recent study of 59 swimming pools showed that the AOX-rate in pools ranges from less than 30 to approximately 300 µg/l, with half of the pools being between 60 and 120 µg/l (Mannschott, 1995). It should be noted that some of these AOX were introduced by the feed water used to fill and supplement the pools.

Nowadays about 60 % of the OBPs are destroyed in sewage treatment plants (AISE, 1997). With prolonged treatment in sewage treatment plants, about 86 % of the OBPs from household uses of hypochlorite can be degraded by activated sludge. The remaining OBPs still degrade but at a much slower rate (Grimvall *et al*. 1991).

Calculations based on emission data in the Netherlands showed that in 1990, emission after sewage treatment from the domestic use of hypochlorite (2 000 tonnes hypochlorite, expressed in chlorine) was the third most important source of AOX emissions to the aquatic environment (Tukker *et al*., 1995). (The domestic use of hypochlorite in the Netherlands has decreased to 1 040 - 1 300 tonnes in 1994).

On the basis of these estimations, it can be calculated that in the Netherlands approximately:

a. 12 tonnes of AOX are emitted due to the use of hypochlorite in households (1,5 % of 2 000 tonnes hypochlorite; 60 % of the AOX destroyed in sewage treatment plants);

b. 8 tonnes of AOX are emitted due to the use of hypochlorite in public swimming pools (0,75 % of 2 700 tonnes hypochlorite, 60 % of the AOX destroyed in sewage treatment plants because most of the swimming pools in the Netherlands are linked to the sewer network).

The total AOX-emission to the marine environment in the Netherlands was probably between 150 and 200 tonnes in 1990, so the contribution of the use of hypochlorite in households to the total AOX-emission in the Netherlands was approximately 7 % and approximately 5 % by the use in public swimming pools. For all hypochlorite use (domestic and industrial) the contribution to the total AOX-emission was approximately 30 % (Tukker, 1996). In the case of France, the contribution of the use of hypochlorite in swimming pools to the total AOX-emission was estimated to be of a maximum order of one thousandth of the total flow of AOX.

It can be stated that based on the analysis of relevant literature (Colgate-Palmolive, 1990; Hagendorf & Rode, 1990; Grimval *et al*, 1991; Abamou & Miossec, 1992; Smith, 1994; Henkel, 1996; Ong *et al*, 1996; Jha *et al*, 1996) there are no indications that the domestic use of hypochlorite bleach is a source of OBPs which could be classified as toxic, persistent and bioaccumulative (TPBs) (AISE, scientific dossier, 1997 in preparation).

Mutagenic activity is frequently detected by using ames tests in concentrates of chlorinated drinking water (Coleman *et al*., 1984). Samples of settled primary municipal sewage treatment works diluted in sea-water, which could *de facto* contain OBPs from bleach use and tap water have, however, recently been tested negative for genotoxicity. Following the in vivo exposure of embryo-larvae of the marine worm, *Platynereis dumerii*, examination of cells for chromosomal aberrations demonstrated the absence of cytogenetic damage in all samples tested (Jha *et al*. 1996).

IV BY PRODUCTS GENERATED DURING SWIMMING POOL WATER TREATMENT

Water is supplied to swimming pools, in strict compliance with the regulations, by using bacteriostatic drinking water containing a slight excess of free chlorine (usually 0,1 mg/l).

Each swimmer naturally introduces organic matter which will "consume" chlorine. In order to maintain the dose of chlorine necessary for disinfection purposes, it will therefore be necessary to inject hypochlorite, the amount of which will depend on the number of swimmers and their behaviour (hygiene).

According to university studies (Prof. SEUX), one swimmer equivalent (i.e. one swimmer for one hour) requires 0,5 ± 0,5 grams of chlorine.

This theoretical value was confirmed in a practical survey which showed that chlorine consumption varied between 10 and 15 g per swimmer equivalent (this figure incorporates the other sanitary uses of "chlorine" in swimming pools, i.e. cleaning/disinfection of surface areas and toilets).

Three kinds of organic matter which are introduced by each swimmer can be distinguished:

a. urine;

b. sweat;

c. miscellaneous (e.g. saliva, secretions, dead skin, cosmetics).

In chemical terms, this organic matter consists mainly of urea, creatinine and amino-acids.

It is the reaction of hypochloric acid and the hypochlorite ion with these compounds which forms "by-products".

Without being exhaustive, and keeping in mind that the formation of micro pollutants cannot be excluded, the following list shows the main by-products quoted in the literature:

- chlorinated, brominated and chlorobrominated "trihalomethanes" of which chloroform represents approximately 90 % of this category of by-products;
- chloramines (mono and dichloramines, trichloramine entering the air), which have disinfectant properties, though far inferior to that of hypochlorite;
- di and trichloroacetic acids;
- chloral hydrate (which is also a disinfectant);
- dichloroacetonitrile.

Several recent analytical campaigns carried out in two indoor swimming pools by the University of Poitiers and the University of Barcelona have led to the same conclusions.

The above considerations only relate to physical and chemical processes which occur inside the swimming pools. As some unreacted chlorine remains in the overflow and purge of the swimming pools, it can be assumed that a few by-products are being produced via chlorination of organic matters in the sewer system. However, this contribution to the AOX formation is assumed to be of secondary importance compared to the AOX formation from the swimming pool basins. On the other hand, the kind of products synthesised should be of same nature as those resulting from the use of hypochlorite in household (see corresponding study).

The chlorine and sodium hypochlorite consumption can be estimated for Spain, France and the Netherlands as follows:

Table 1 Chlorine / sodium hypochlorite consumption and chlorinated organic matter in discharged water from swimming pools
(data evaluated in 1996)

	Spain	France	Netherlands
chlorine / sodium hypochlorite consumption (expressed as 100 % chlorine in t/year)	7 100 (?)	1 500 - 2 000	1 800
chlorinated organic matter in discharged water * (expressed as AOX in t/year)	35,5	7,5 to 10	9

* calculated by using the ratio of 0,5 % of chlorine converted to chlorinated organic matter in discharged water, of which only a part reaches the marine environment.

This range applies to the overall consumption for swimming pools in the countries mentioned in question. It would be judicious to consider only the proportion which is likely to find its way into the Atlantic and the North Sea.

It should be noted that the values given in Table 1 represent the quantities of AOX "leaving swimming pools" and not the quantities emanating from swimming pools and reaching the marine environment.

Indeed the THM contained in these AOX will be stripped before reaching the sea. Moreover, as most swimming pools emptying takes place in built-up areas and are in most cases linked to the sewer network, part of these AOX will be removed in wastewater treatment plants.

In France, the average quantity of AOX discharged in rivers and water courses flowing into the Atlantic (which represent an average flow rate of 2 000 m3/second), is of the order of 2 000 tonnes per year. On this basis, the amounts of AOX introduced which are attributable to public swimming pools treated with sodium hypochlorite and chlorine are therefore, in the case of France, of a maximum order of one thousandth of the total flow of AOX.

Questions about the suitability of AOX as a parameter representative of the environmental impact (e.g. the relation between AOX and hazard) are not dealt with in this document. This issue is being further investigated separately in the framework of DIFF.

Analytical studies carried out in various swimming pools have shown that virtually all the AOX values measured can be attributed to the amount of the following principal substances in the water:

- trihalomethane;
- chloral hydrate;
- dichloroacetonitrile;
- dichloroacetic acid;
- trichloroacetic acid.

According to the studies, these components represent virtually all the AOX values measured. The unidentified proportion is therefore low.

After emission into the environment, the following products disappear from the surface water:

- trihalomethanes are evaporated;
- chloral hydrate is converted to trichloroacetic acid;
- dichloroacetonitrile is hydrolysed.

The only two products which remain in observable quantities are dichloro and trichloroacetic acids, of which it is known:

a. that they are naturally present in the environment (e.g. rainwater contains between 0,2 and 2 ppb of trichloroacetic acid, and this has been the case for centuries);

b. that they are only toxic or ecotoxic to a modest degree, but not bioaccumulable.

Thus it has been possible to show that rainwater contains between 0,2 and 2 ppb of trichloroacetic acid, and this has been the case for centuries.

As regards the question of possible micropollutants, i.e. products which are both persistent, toxic and liable to bioaccumulable (PTB), the studies reveal that:

a. none of these products were found;

b. the most products are identifiable (i.e. depending on the case, they represent a high or the total proportion of the AOX measured, which leaves little or no room for unidentified products);

c. analysis of the aromatic products contained corresponds to a low value.

V CONCLUSIONS

The unidentified proportion of individual OBPs formed by hypochlorite use in swimming pools is low, when identification took place before the emission flows into the sewer network. A large part (75 %) of the individual OBPs constituting the AOX emission of sewage-treatment-effluents, mainly coming from the domestic use of hypochlorite, remains unidentified. Because of this lack of knowledge, a firm conclusion on the absence of a risk for the environment cannot be drawn. The complex and fluctuating circumstances in effluents from sewers is one of the factors which contribute to this uncertainty. However, based on available data, there are no indications that OBPs, which originated from the use of hypochlorite, will lead to a risk for the environment.

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Part II

Background Document on Compact Detergents

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I SUMMARY AND CONCLUSIONS

The issue of the environmental impact of detergents and the formulation of appropriate measures to reduce this impact has been on the work programme of the Working Group on Diffuse Sources (DIFF) of the OSPAR Commission for several years. This has resulted, *inter alia*, in the adoption of PARCOM Recommendation 93/4 on the Phasing Out of Cationic Detergents DTDMAC, DSDMAC and DHTDMAC in Fabric Softeners. Recently, attention has been paid to the environmental advantages of the use of compact detergents instead of traditional detergents.

In this background report, information is provided on the reductions of pollutant loads as a consequence of the switch from traditional to compact detergents. Section II shows an overview of (laundry) powder detergents use throughout Europe and possible reduction data. Some additional information from various OSPAR Contracting Parties is presented in section III. Environmental benefits of compact powders are described in section IV. Finally, section V deals with dosage deviations.

At its annual meeting in 1997, DIFF examined the information contained in this report and agreed that there was insufficient support for the preparation of a measure to address the switch from traditional to compact detergents.

The following arguments were put forward by one or more Contracting Parties against preparing such a measure within OSPAR:

a. the conversion from traditional to compact detergents is not the only measure to reduce environmental impact resulting from laundry detergents. A combination of such a conversion together with other instruments (e.g. ecolabelling of detergents, preferred use of ingredients with improved ecological properties, low temperature washing) was regarded as the best way to improve the environmental profile of detergents use;

b. the European Soap and Detergent Industry (AISE) has drawn up a code of good environmental practice for household laundry detergents; several instruments are part of this code. This code has been assessed by the European Commission (cf. report EC 4402, an assessment of the code of good environmental practice for household laundry detergents, draft final report to the European Commission, October 1997). In addition, the European Union (EU) is in the process of revising European Community legislation on biodegradable detergents;

c. surfactants in detergents had previously been identified as non-hazardous; moreover the value of reductions of sulphate inputs to the marine environment were questioned.

II OVERVIEW OF (LAUNDRY) POWDER DETERGENTS USE THROUGHOUT EUROPE AND POSSIBLE REDUCTION DATA

The laundry powder market can be split up between:

a. traditional (or so called regular) products, which are typically large volume boxes with recommended dosages around 150-180 grams per wash[1]; and

b. compact products, packed in small boxes with recommended dosages of 80-100 grams per wash.

In the last years, so called supercompact detergents have been introduced with even lower dosages, typically between 60-80 grams. These will be considered in this report as part of the compacts.

The main reason for using traditional detergents seems to be the traditional washing habits of consumers and the perceived value (3 kg detergent for the price of 1,5 kg supercompact). However, the price per wash dosage is often not significantly different between traditional and compact products.

According to recent studies of consumer organisations in the Netherlands, (super) compact detergents wash better than traditional detergents with even as low as half the dosage. In the Netherlands, some international detergent manufacturers have removed their traditional products from the market and only sell compact detergents. There does not seem to be a technical reason for using traditional detergents.

As far as the market development is concerned, it seems that consumers switched from using traditional detergents to compact detergents more or less directly after the introduction of the latter in the period of 1988-1990. In the last two years, signals indicate that the use of compact detergents seems to have stabilised or even reduced. New initiatives are needed to increase public awareness of the advantages compact detergents.

Data on the use of laundry powder detergents in various countries around Europe are given in Table 1 and reflect the percentage of the total tonnage of detergents (compact/supercompact and traditional products) used in a country. The data of Table 1 (and also Table 2) have originally been provided by industry and were amended on the basis of information provided by various OSPAR Contracting Parties.

1 In the UK, leading brands have recommended 108 grams as dose for regular (traditional) powders and 75 grams as the dose for compact powders.

Table 1: Powder and Liquid Detergent Usage in %

	Powder		Liquids	
Country	**(Super) Compact**	**Traditional**	**Compact**	**Traditional**
Belgium	25	75	20	80
Denmark	40	60	87	13
Finland	68	32	0	100
France	17	83	35	64
Germany	60	40	53	47
Ireland	13	87	72	27
Netherlands	84	16	72	27
Portugal	1	99	-	-
Spain	11	89	0	100
Sweden	83	17	69	31
Switzerland	58	42	73	27
UK[2]	37	63	39	61

The data given in Table 1 show a great diversity with respect to the percentage of conversion from using traditional detergents to using compact detergents:

a. In the northern countries (Sweden, Germany and the Netherlands), the conversion is greatest with 60 % and higher;

b. France and Spain have the lowest conversion rate, with the use of compact detergents below 20 %;

c. in Belgium, Switzerland, Denmark and the UK, the conversion rate lies somewhere between;

d. the usage of liquid detergents shows, in comparison to the usage of powder detergents, that:

   (i) in some countries there is a reverse trend (i.e. less consumers switch from using traditional liquid detergents to using compact liquid detergents);

   (ii) other countries have an even higher value of conversion-percentage for liquid detergents than for powder detergents.

Table 2 below gives an example of emission reduction by switching from traditional detergents to compact detergents. This example is for a specific washing condition (medium water hardness and average soil level) and using an average formulation.

2 The UK questions the basis which has been used to calculate the UK figures in Table 1. The dosages recommended in the UK are significantly different (cf. footnote 1) from the doses of 150-180 grams for traditional and 80-100 grams for compacts which have been used as the basis for the figures in this table.

Table 2: Example of Emission Reductions Due to Conversion from Traditional Detergents to Compact Detergents

	Traditional detergent (g) (1)	Compact detergent (g) (1)	Reduction (%)	Savings per wash (g) (2)
Dosage (3)				
	160	95	41%	65
Ingredients in the wash				
Surfactant	21	15	31%	7
Builder	33	26	20%	7
Buffer	42	15	65%	27
Bleach	25	19	23%	6
TAED (4)	3	4.5	-50%	-

(1) Average of typical product compositions in grams
(2) Saving per wash in grams
(3) Recommended dosage for medium water hardness
(4) TAED = tetra acetyl ethylene Daikin; bleach activator with good biodegradable properties (in the presence of TAED, bleach is already active at lower temperatures).

Table 2 shows the reductions (%) and savings (grams) of detergent and detergent ingredients by using compact detergents instead of traditional detergents. In general, and taking into account all possible washing conditions, such conversion would substantially reduce the total amount of detergent ingredients used for domestic purposes.

It should be noted that:

a. the reductions and savings are not only due to the lesser amount of buffer filler material sulphate, which is used in traditional detergents;

b. the use of compact detergents will also considerably reduce the amount of surfactants and builders;

c. by switching to compact detergents substantially less packaging waste will be substantially generated.

The data given in Table 1 relate only to compact detergents. New super compacts use even lower dosages (60-80 g).

In the Netherlands, representing a small country with a constant market, a reduction of 40 000 tonnes has been achieved. Potential reductions in other countries are dependent on the number of households using, and the market share of, compact detergents. But even markets, which already show a significant conversion to compact detergents, still have the potential for further significant reductions in absolute emissions.

III ADDITIONAL INFORMATION FROM OSPAR CONTRACTING PARTIES

3.1 Sweden

As the result of the success of the 'Swan- and Bra miljoval' ecolabelling schemes, about 85-90 % of the Swedish products carry an ecolabel. This figure applies for textile surfactants, but the figures for manual dishwashing detergents and all purpose cleaners are high as well. Both schemes require that the products on the market are colour detergents without optical brighteners. In the 'Bra miljoval', bleach is not allowed. The modern compact detergents meet the "ecolabel" requirements of both schemes.

As a result of the governmental proposal on chemicals, the use of the cationic surfactant DSDMAC has been phased out. Moreover, manufacturers and importers of detergents, dish washing and cleaning agents committed themselves to reduce the use of surfactants that are not readily biodegradable according to OECD's "Guidelines for Testing of Chemicals".

3.2 The Netherlands

Compact detergents have been very successful in the Netherlands. The total volume of textile detergents used decreased from 134 000 tonnes in 1990 to 94 000 tonnes in 1995, representing a saving of 30 % (40 000 tonnes). This decrease is attributed merely to compact products as the market in terms of the number of washes carried out remained constant. Detergent industry has committed itself to continue to further reduce emissions in the future.

As the rate of use of compact detergents seems to have stalled and in order to avoid a switch back to traditional products, industry will set up a monitoring system and will annually report market developments on textile detergents and dishwasher products.

3.3 Germany

For medium water hardness and normally soiled clothes, the release of surfactants per standard wash (using traditional detergents) is about 20 to 30 % more compared to using respective compact detergents. Reductions of inorganic salts (without bleach and builders) are even higher (about a factor of 3,5). Moreover, using compact detergents saves packaging material and transport energy.

Recently a re-introduction of the so-called "JUMBO-PACKAGES" containing traditional heavy duty detergents in big 10 kg boxes has been observed in Germany.

3.4 Finland

Finland participates in the Nordic environmental labelling work (cf. comments from Sweden above) and through that work Finland has recommended customers to choose 'Swan'-labelled products.

3.5 Portugal

The total usage of compact detergents in Portugal has decreased from 5 % in 1990 to < 1 % in 1996. The reasons and explanations for this situation are as follows:

a. consumers have a tendency to overdose compact detergents;

b. higher price of compact detergents;

c. in Portugal traditional (regular) detergents are of high quality, in many cases higher than in some other European countries.

IV ENVIRONMENTAL BENEFITS OF COMPACT POWDERS

As already stated, the introduction of compact detergents gives a considerable reduction in use of not only sulphates but also of surfactants and builders. The environmental benefits of compact detergents have been confirmed by research of the UBA.

In 1991/1992, the German Federal Environment Agency (UBA) contracted the German Öko-Institute to conduct a research project "Produktlinie Analyse Detergents" (PLA). In contrast to a Life Cycle Inventory (LCI), a PLA also considers economic and social aspects. The German detergent industry was asked via the detergent industry association (IKW) to participate in the project and to provide data on detergent manufacturing and raw materials.

Detergent types considered in this project cover, among others:

a. regular powders;

b. compact powders; and

c. liquid compacts.

Aspects considered in UBAs "PLA / LCA Detergents" projects include:

a. ingredients[3] of all relevant detergents;

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[3] builders (zeolithe, percarboxylate,natriumcitrate, -silicate), bleach/activators (percarbonate, perborate, TAED), other (natriumsulfate, -carbonate, carboxymethylcellulose, optical brighteners, PVP)

d. model formula for detergents (one average formulation each) for the three detergent types;

e. transports;

f. washing of cloth (with variations of washing temperatures, loads of washing machines, dosage of detergents and washing machine technologies);

g. drying of cloth;

h. social aspects of renewable raw materials for detergents;

i. toxicity of waste water (based on EU-Ecolabel criteria).

Preliminary results of the project are (cf. UBA Texte 1/97, Ecological Assessment of Washing Agents and Cleaning Agents; Comprehensive Product Assessment of Washing and Washing Agents):

a. regular powder detergents are worse from an environmental point of view compared to compact detergents (liquids, powders);

b. consumers can influence the environmental impact of washing significantly. Properly loaded washing machines and low temperatures (30°C) can reduce energy and emissions by about 50 %. This can also lead to cost savings of 50 % for the consumer;

c. consumers do not save time today when using washing machines. The reason for this is that today, compared to 40 years ago when consumers had no washing machines, the amount of laundry is twice as high.

V DOSAGE DEVIATIONS

It has been questioned that a switch from traditional (high dosage) to compact (low dosage) products might lead to an overdosing of detergents.

At least the experience gained with compacts in the Northern countries has shown that overdose is not a problem. Industry has made efforts to inform the public on how to handle compacts both by adding adjusted dosing spoons and in their advertisement. In usage studies with consumers it has been shown that (super) compacts are correctly dosed in practice. The reported considerable reduction of emissions in the Netherlands by 28 % from 1990 to 1995 coincides with an increased usage of compact detergents by estimated 70 %, proofing that a reduction of emissions can be realised by switching to compact detergents.

However, experience in other countries shows that consumers frequently overdose compact detergents despite the efforts to advertise and give instructions on the correct dosage. Portugal (cf. information given above) and Spain have reported this problem to DIFF. In the UK, a survey of actual usage carried out by one manufacturer showed that for traditional detergents, an average dose of 107 grams was used, whereas for compact detergents, an average dose of 98 grams (considerably higher than recommended) was used.

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