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OxTube Integrated Water Clarification for Removal of Pharmaceutical Residues and Disinfection

Juhani Pylkkänen, CTO, SansOx Ltd.
Biel 21, 3923 Toerbel, Switzerland
Juhani.pylkkanen@t2o.fi

Abstract

A hermetic and seamless water treatment process called OxTube Integrated Clarification and some selected applications are discussed here. The seamless treatment procedure consists of four main functions as follows: separation of soluble ingredients, activation of molecules, clarification and replacement dissolving. The following applications are selected and discussed briefly here:

- Removal of pharmaceutics and some other substances from the purified city waste water
- Disinfection of hospital waste water

Keywords: Pharmaceutical residues removal; Ozone disinfection; OxTube Ozone Treatment; Water clarification; Dissolving

Basics of OxTube Water Treatment Process

A new hermetic water treatment called OxTube Integrated Clarification and some of its applications are discussed here. There are many ways and combinations to apply this new water treatment technology. In order to understand the phenomena itself only basic principles are presented in this context. The applications selected are presented briefly by the key results and measures achieved.

OxTube treats the water in flowing condition in the hermetic tube condition. It separates soluble ingredients from the water, splits molecular and ionic structures, activates molecules, and clarifies the water and replaces the separated molecules by desirable gases like air, oxygen and carbon dioxide. These treatment functions happen within a second or less in its seamless process. The air gases are sucked by the vacuum effect in the nozzle zone and led directly in middle of the main flow. All the other gases can be sucked, too or fed into the nozzle zone. The gases and chemicals can be mixed evenly with the main flow in the nozzle zone. The meeting probability of the molecules is high and so, chemical reactions follow immediately in the hermetic condition. Next the foggy mixture of water and gasses is turned back to liquid with overdosed gas bubbles.

The principle of OxTube Water Treatment is presented In Fig.1 with a functional prototype visually. There are four main functions following each other seamlessly in one tube or in separate

modules by function. The water is clarified and dissolved with desirable ingredients, e.g. air gases in the tube within a second or less. The molecules separated from the water and injected or sucked in the water flow meet each other in separation, activation and clarification zones with high probability. Finally, overdosing dissolves in the clarified water. The entire clarification process is very well controlled due to its hermetic procedure.

OxTube efficiency on separation of soluble ingredients and molecular activation is shown visibly in Fig. 2 left, and after clarification of one second right. The water used is high quality Swiss Alpen tap water.

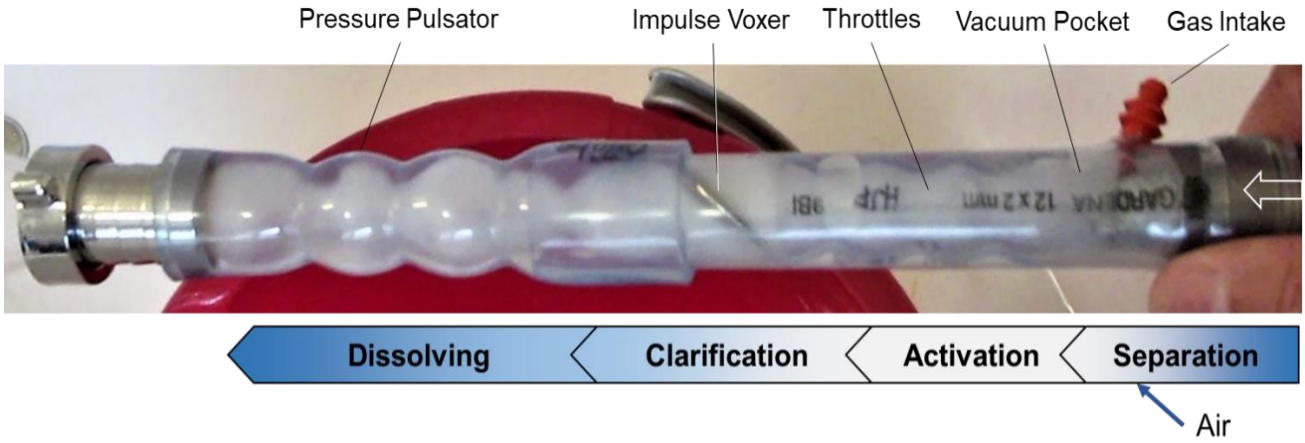

Fig. 1 OxTube Water Treatment Process illustrated visually with air suction. The seamless treatment of clarification and replacement dissolving is performed within a second or faster. The water is all the way an even mixture of air, water and water drops. Meeting probability of molecules is very high.

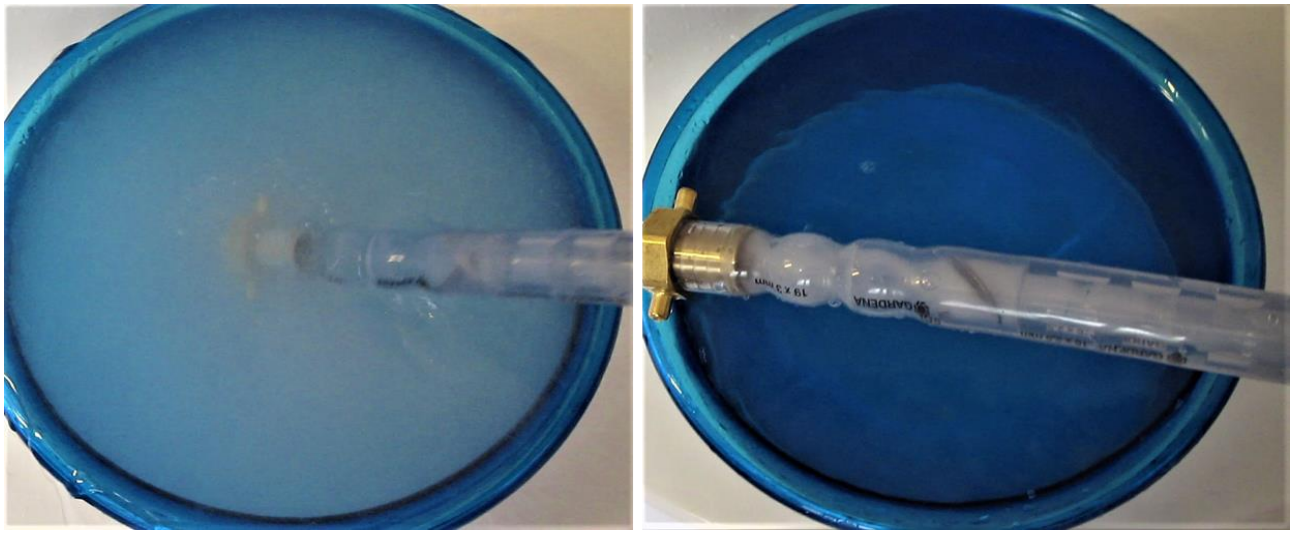

Fig. 2 Efficiency of OxTube Air treatment. Swiss Alpen tap water after the soluble ingredients separation and molecular activation on the left, and after the air clarification and dissolving of one second on the right. The separation, activation, clarification and replacement dissolving are performed seamlessly within a second in OxTube.

Address
Niemenkatu 73
15140 Lahti, Finland

GSM
+358 40 8669506
+358 500 603020

E-mail
juhani.pylkkanen@t2o.fi
info@sansox.fi

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The replacement dissolving efficiency of OxTube by laboratory test runs and two applications is shown in Fig. 3. Theoretical maximum of oxygen concentration was achieved in test runs within a second and in an installation of Caviar farm within three seconds. The concentration stayed stable at least four weeks in the treated water at the laboratory tests.

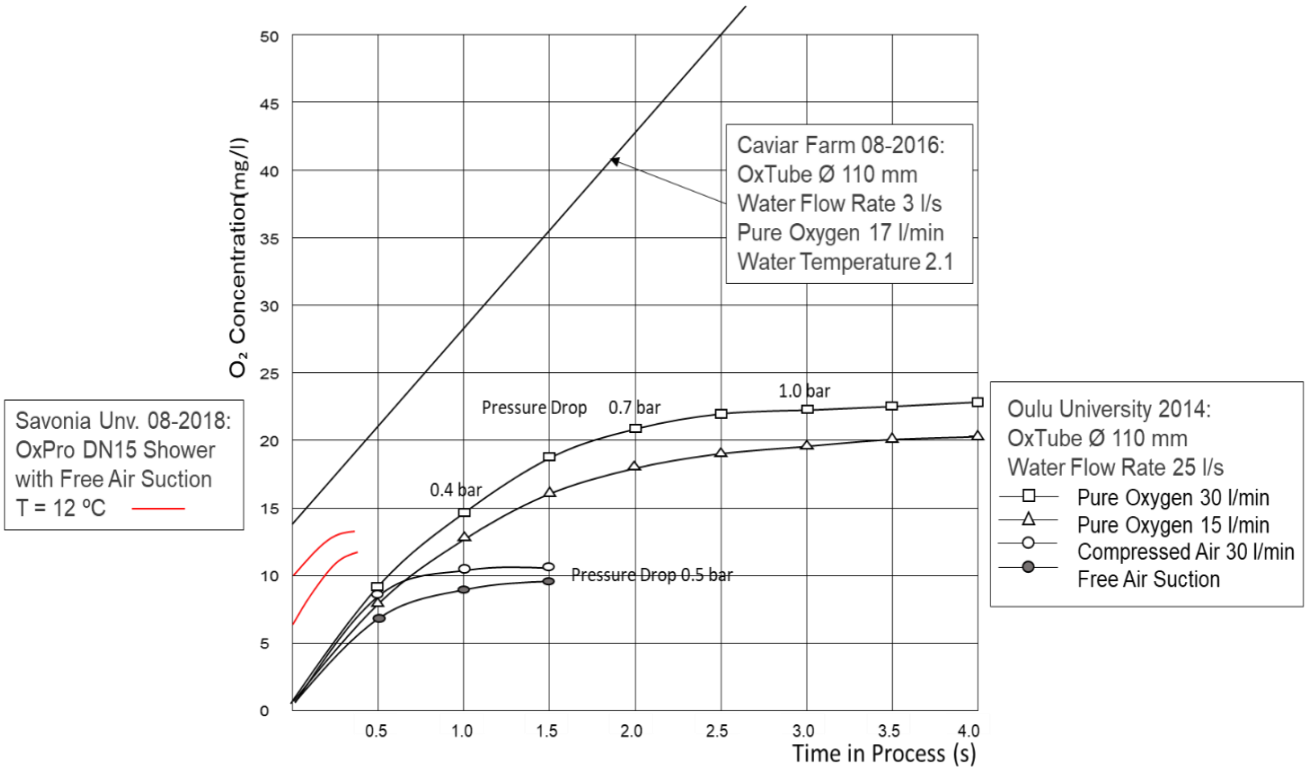

Fig. 3 Replacement Dissolving Efficiency by early research and two applications

Removal of Pharmaceutical residues and Other Substances

OxTube Ozone was tested and the process verified in removal of pharmaceutical residues and some other substances out from the purified city waste water of Kuopio Finland. Ozone was fed directly in OxTube Integrated Clarification and Dissolving Tube from the ozone generator. The average reduction of the pharmaceuticals and chemicals listed in Table 1 was measured as 87 %, and just pharmaceuticals as 90 %. Further, negligible ozone residues and high oxygen concentration were measured in the treated waste water. The total process time was only 0.7 second.

The OxTube process functions well and as designed in the pharmaceuticals removal; separation, breaking and activation, and further clarification and replacement dissolving. The reduction rate can be improved with fine adjustment due to fact that this trial was performed first time with rough hypothetical data. However, OxTube Ozone Process was identified an efficient and low energy consumption technology in pharmaceuticals removal, and at the same time in waste water clarification and disinfection. There are singes measured that removal of pharmaceutical residues and full reduction of viruses can be completed with clean air or a mixture of air and ozone.

Address
Niemenkatu 73
15140 Lahti, Finland

GSM
+358 40 8669506
+358 500 603020

E-mail
juhani.pylkkanen@t2o.fi
info@sansox.fi

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OxTube Ozone can be installed in the waste water outlet pipe without additional energy consumption, only the ozone generator needs electrical power. Ozone consumption is little due to high probability of the molecular meeting in OxTube. Recycling of overdosed ozone directly to OxTube gas channel can be easily implemented.

Table 1. Removal of pharmaceutics and some other substances from the purified city waste water of Kuopio Finland with OxTube Integrated Clarification treatment within a second. Complex molecular structures of the pharmaceutics are split in separation phase before activation and clarification.

Pharmaceutics and other substancies	OxTube Ozone Treatment			Present Method 1		Present Method 2	
	Initial µg/l	Residue µg/l	Reduction %	Resudue µg/l	Reduction %	Residue µg/l	Reduction %
Cetirizine	5,8	0,006	99,9	4	<20	4	<20
Benzotriazole	2,8	0,896	68	1	63	2	<20
Furosemide	1,8	0,054	97	1,4	<20	1,4	<20
Hydrochloricazide	1,8	0,162	91	1,4	<20	1,4	<20
Diclofenac	1,5	0,004	99,7	1,2	<20	1,2	<20
Lamotrigine	1,4	0,756	46	1,1	<20	1,1	<20
Losartan	1,2	0,005	99,6	1	<20	1	<20
Losartan	1,2	0,246	79,5	0,7	<20	0,7	<20
5-methylbenzotriazole	0,83	0,191	77	1,4	<20	1,4	<20
Diatrizoate	0,70	0,147	79	0,6	20	0,5	<20
Atenolol	0,56	0,118	79	0,42	<20	0,35	22
Carbamazepine	0,53	0,048	91	0,4	<20	0,4	<20
Clozapine	0,53	0,053	90	0,4	<20	0,4	<20
Bisoprolol	0,50	0,105	79	0,1	77	0,4	<20
Tramadol	0,43	0,043	90	0,3	<20	0,3	<20
Citalopram	0,42	0,013	97	0,2	<20	0,2	<20
Piperacillin	0,29	0,009	97	0,32	48	0,2	<20
4-acetamidoantipyrine	0,29	0,015	95	0,15	21	0,15	<20
Azithromycin	0,20	0,012	94	0,14	<20	0,14	<20
Mirtazapine	0,17	0,006	96,4	0,08	31	0,11	<20
Atorvastatin	0,14	0,013	91	0,09	55	0,09	66
Propanolol	0,11	0,010	91	0,09	<20	0,09	<20
Quetiapine	0,11	0,006	95	0,08	<20	0,08	<20
Naproxen	0,10	0,020	80	0,07	<20	0,07	<20
Desloratadine	0,081	0,022	73	0,1	25	0,09	33
4-formylaminoantipyrine	0,077	0,022	71	0,04	52	0,06	<20
Bezafibrate	0,069	0,014	79	0,01	78	0,05	<20
Fluvastatin	0,068	0,011	84	0,07	26	0,08	<20
Metronidazole	0,064	0,035	45	0,04	23	0,05	<20
Sotalol	0,064	0,010	84	0,06	<20	0,06	33
Sulfamethoxazole	0,063	0,011	83	0,05	<20	0,05	<20
Ketoprofen	0,059	0,042	28	0,03	62	0,02	80
Sertraline	0,05	0,011	79	0,03	<20	0,03	<20
Sulfadiazine	0,042	0,013	70	0,03	<20	0,03	<20
Clarithromycin	0,033	0,011	68	0.03	<20	0,03	24
Ramipril	0,031	0,008	74	0,02	<20	0,02	<20
Amiloride	0,023	0,014	38	0,01	<20	0,01	<20
Roxithromycin	0,008	0,003	62	0,01	<20	0,01	<20
Xylometazoline	0,013	0,002	86	0,006	<20	0,006	<20
Warfarin	0,007	0,020	<20	0,02	24	0,02	<20
Caffeine		0,018	<20	0,018	<20	0,011	52
Verapamil		0.010	<20	0,01	<20	0,01	24
Total Drug Emission Load Reduction	**24,162**	**3,202**	**86,75**	**17,194**	**28,83**	**18,317**	**24,18**

Address
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15140 Lahti, Finland

GSM
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E-mail
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info@sansox.fi

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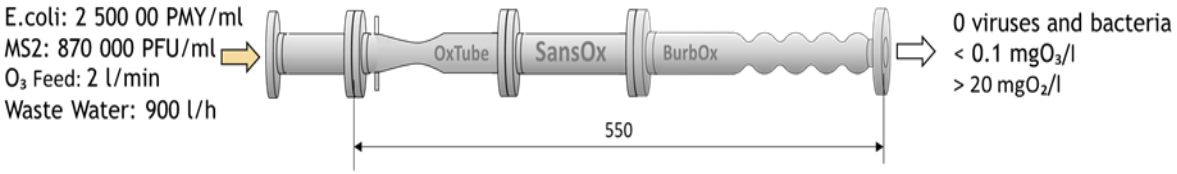
Ozone Disinfection

OxTube Ozone was tested and verified in disinfection of various water matrices at Savonia University of Applied Sciences during 2017 and 2019. A typical measure sheet is presented in Table 2. Reductions of 100 % were measured in the most test runs in elimination of E coli and MS2. Further, only negligible ozone residues were identified after the OxTube Ozone Treatment of 0.7 second. Ozone feed was set in the minimum level of the ozone generator. Ozone consumption can be reduced significantly with a lower capacity ozone generator related to mass flow and overdosed ozone recycling. The high reduction is based on the high meeting probability of ozone and microbes in OxTube, and the breaking effect in its nozzle zone. Reduction of 60 % in MS2 was measured with air suction without ozone.

Table 2. Disinfection efficiency of the Integrated Water Clarification of OxTube: 100 % Reduction of E.coli and MS2 achieved with O_3 feed of 2 l/min within 0.7 second, oxygen concentration raised over MR 20 mgO_2/l, no significant ozone residues / Savonia University of Applied Sciences in Kuopio

THL/Summary of Analysis April 3, 2018 - OxTube DN20+BurbOx, water flow rate 900 l/h														
THL Code	Sample	E.coli PMY/ml	Log-red	Reduction (%)	MS2 PFU/ml	Log-red	Reduction (%)	T (°C)	EC (µS/cm)	pH	Turbity (NTU)	Ozone (mg/l)	Oxygen (mg/l)	
18v0347	Test Water	2			1			12,8	283	7,732	0,68	0,03	10,26	
18v0348	Inoculum before Disinfection	2 500 000			870 000									
18v0349	0 mgO_3/l through the system	1 700 000			340 000			12,4	285	7,875	0,46	0,02	11,65	Air suction
18v0350	4.8 lO_3/min	<0,001 (MR.)	>9,23	99,99999994	<2 (MR.)	>5,27	>99,9995	13,2	285	7,811	0,31	0,10	> MR.	>20 mgO_2/l
18v0351	4.2 lO_3/min	<0,001 (MR.)	>9,23	99,99999994	<2 (MR.)	>5,27	>99,9995	12,6	294	7,833	0,27	0,14	> MR.	>20 mgO_2/l
18v0352	3.7 lO_3/min	<0,001 (MR.)	>9,23	99,99999994	<2 (MR.)	>5,27	>99,9995	12,9	288	7,727	0,44	0,10	> MR.	>20 mgO_2/l
18v0353	3.2 lO_3/min	<0,001 (MR.)	>9,23	99,99999994	<2 (MR.)	>5,27	>99,9995	14,3	279	7,838	0,37	0,10	> MR.	>20 mgO_2/l
18v0354	2.6 lO_3/min	<0,001 (MR.)	>9,23	99,99999994	<2 (MR.)	>5,27	>99,9995	14,0	289	7,846	0,44	0,08	> MR.	>20 mgO_2/l
	2.0 lO_3/min	1	6.5	100										



Brief Summary

SansOx has developed a unique water treatment technology called OxTube Integrated Clarification and Dissolving powered by the kinetic energy available in the flowing water. The seamless treatment consists of molecular separation and activation following with clarification and replacement dissolving functions. The process is hermetic and well controlled. There are no movable parts, energy consumption is low, service needs are little, and so, the operational costs are low. Various water matrices as well as any other liquids can be treated optimized way by the OxTube Integrated Clarification and Dissolving Process.

Address
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GSM
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+358 500 603020

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info@sansox.fi

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