THE ROLE OF AERATION ZONE IN AN INTEGRATED PHYTOGREEN SYSTEM FOR BOD, COD AND SS REMOVAL FROM WASTEWATER IN CONVENTIONAL OXIDATION POND.

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Abstract. Water is the basic element that we use in our daily life. The failure of proper wastewater treatment from the plant to the river stream is one of major factors for the degradation of water quality. Phytoremediation system was being started over 10 years ago and is now rapidly developing. The treatment of wastewater using specific aquatic plants has been proven to be efficient on-site. This technology removes harmful chemicals from the ground when the roots of the plants absorb water and nutrients from polluted soil, streams and groundwater. Aeration is a part of the wastewater treatment process, this process aims to remove and break several elements in wastewater. Aeration process provides oxygen to the water, increasing dissolved oxygen content to increase the oxidization of pollutants. Two samples of wastewater were taken from the aeration zone and the samples were being tested with parameters like BOD, COD and Total Suspended Solids. These parameters would then determine the standard of the water being released to the river after going through the aeration zone in an integrated phytogreen system. There were two methods of experiments being conducted to test these water parameters which were the in-situ and ex-situ experiments according to The Examination of Water and Wastewater (APHA; AWWA; WEF, 2005). 5.2.1.

Aeration zone has been successful in lowering the value of Chemical Oxygen Demand and Biochemical Oxygen Demand. Aeration zone has lowered 97% of BOD and 96% of COD in this study. The overall removal efficiency for BOD and COD were 98.1% and 97.6% respectively. Suspended Solids has been decreased at 85% through the aeration zone, and 90% after the overall process. The concentration of suspended solids in this integrated system was in Standard A. As a conclusion, aeration zone has enhanced several parts of the phytogreen integrated system.

Keywords: phytogreen, aeration zone, wastewater, oxidation pond.

Introduction

This study was to determine the performance and characteristics of aeration zone in an integrated phythogreen system. Throughout the study, we could speculate the best performance and characteristics of the aeration zone in order to suffice the integrated phytogreen system. The study was being conducted in Universiti Malaysia Pahang (UMP) laboratory and the samples were being collected from Taman Anggerik Oxidation Pond at Skudai, Johor. Phytogreen system is a wastewater treatment plant using phytoremedition, phytostabilisation and phytotransformation processes. **(**Syukor and Sulaiman, 2014a) Aeration zone is a zone in an integrated phytogreen system designed to increase Oxygen in water for decomposition by bacteria and lowering the Biochemical Oxygen demand (BOD) and Chemical Oxygen Demand (COD) in wastewater.

Phytoremediation is an advanced green technology, which maximizes the potential of specific plants for wastewater treatment. It is a process of decontaminating soil or water by using plants and trees to absorb or break down pollutants.(Syukor et al., 2014b) Aquatic plants have the ability to remove contamination in wastewater, by absorption, decomposition and nutrients intake.(Divya Singh, Archana Tiwari and Richa Gupta, 2012) Phytoremediation remediate soils, sediments, groundwater environments and surface water polluted with poisonous metals, organics, solvents, industrial chemical, and other xenobiotic substances.(Rajiv K Sinha et al, 2009)

Phytoremediation uses certain plants ability called hyper accumulators to biologically accumulate, and render contaminants in soils, water and air. (Rajiv K Sinha et al, 2009) An example of application involving phytoremediation process is in abandoned mines. Mining leaves toxic metals such as polychlorinated biphenyls; dumped during manufacture and on-going process of the mines. Certain plants are being used to minimize the effect of toxic metals by phytoremediation process. (Ghosh M and Singh S.P., 2005)

Aeration is the process of bringing water into close contact with air and providing oxygen to water; in other words to expose to the action or circulation of the air, so as to purify.(Collins English Dictionary, 1979, 1986) Oxygen is crucial to oxidize dissolved metals such as iron and remove dissolved gases such as carbon dioxide.(Nyer, Evan K., 1992) The close contact and turbulence made by the aerator, releasing Hydrogen Sulfide, which is a poisonous gas that could be fatal if consumed within 30 minutes.(United States Department of Labor, 2015)

Conventional Oxidation Pond (OP) is used widely for wastewater treatment in Malaysia. This system consists of two ponds, first is the primary pond, which is to retain effluents and the secondary pond which is for natural oxidation process.(National Service Center for Environmental Publications (NSCEP), 2011) Oxidation process is being generated by sunlight which allows algae to run photosynthesis process and provides oxygen into the pond.(Abdel-Raouf, N. et al., 2012) Oxygen is used to perform the aerobic cycles in the pond, and also being used by the microorganisms to decompose organic matter and becomes settled solids.(GE Power & Water (Water & Process Technologies), 2012) The bacteria from the organic matter then use the oxygen from water to release carbon dioxide, ammonia and phosphate,(Water Encyclopaedia; Science & Issues, 2015) then to be used by algae. Algae, with the presence of carbon dioxide and direct sunlight runs the photosynthesis process and also releases phosphate and ammonia to the air, this process is then cycled until all the organic matter decomposed. The settled solids then undergo the anaerobic decomposition by bacteria, and release hydrogen sulphide and carbon dioxide to the air. This process would produce sludge and treat the wastewater to certain qualities. (Burkhead, C E & O'Brien, W J. 1974)

Methodology

Samples were taken from Taman Anggerik, Skudai in Johor Bahru, Johor. The oxidation pond has been upgraded into Phytogreen System pond, which included various aquatic plants. There are 5 zones for samples collection and we collected 15 samples for 30 weeks as shown in Fig. 1. Samples collected were tested in the laboratory. The samples were tested for, Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD) and Total Suspended Solid.

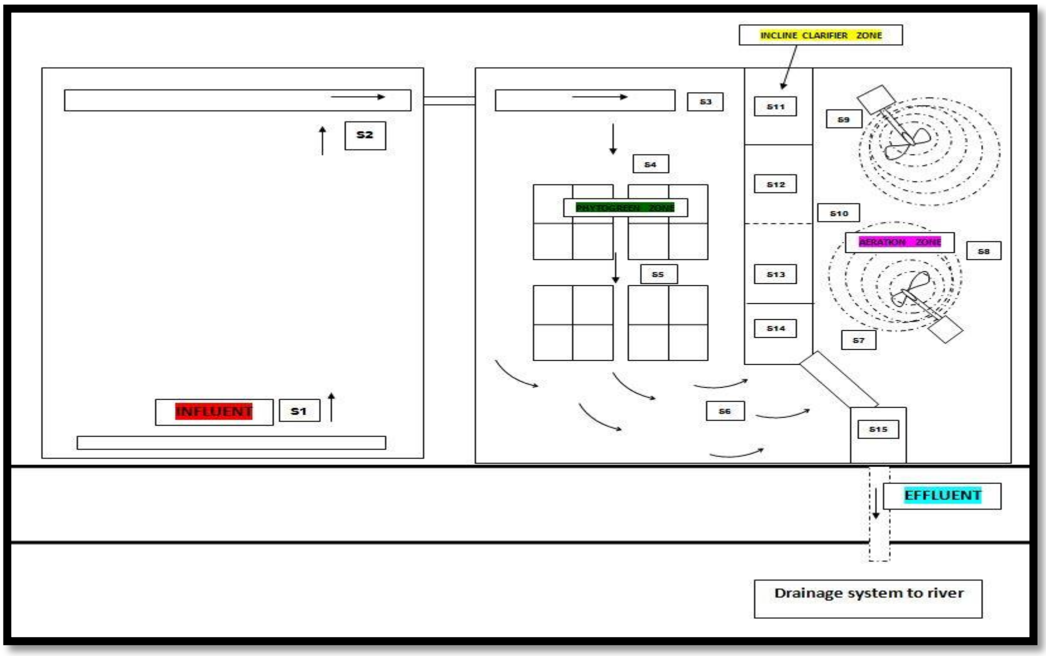

Fig. 1: Layout of Sampling Point

The initial reading of Total Suspended Solid was recorded by using traceable procedure to APHA 4500H+ B (21st Edition), Standard method for the Examination of Water and Wastewater. Based on the HACH DR 5000 method 8000, In House method was conducted to test the Chemical Oxygen Demand (COD) in the samples.

One-way ANOVA was used to find out if there were any significant differences among three or more population means. Except for the fact that these designs have more than two groups they were analyzed in a way similar to the independent-samples t-test. There was still one dependent variable and one independent variable. (The IV just has more than two levels) .The question that ANOVA addresses is whether the populations that the samples come from have the same m . If you reject null, and say, "no," then at least one of the populations has a different m/

Results and Discussions

The average readings for all parameters within 30 weeks are shown in Table 1.

Table 1 | Average reading for BOD, COD and SS Parameters

Samples No.	pH	TEMPERATURE °C	BOD	COD	SS
S1	8.04	30.14	328.73	745.21	251.17
S2	7.89	29.97	291.46	664.05	223.90
S3	7.73	29.80	171.81	205.84	110.05
S4	7.65	29.73	40.49	121.59	39.15
S5	7.62	29.65	22.23	66.34	35.75
S6	7.48	29.57	21.00	63.14	44.71
S7	7.40	29.48	19.52	58.65	56.32
S8	7.42	29.47	19.20	52.67	65.74
S9	7.35	29.48	14.00	32.90	52.94
S10	7.48	29.48	11.41	30.28	37.94
S11	7.62	29.49	10.91	27.67	36.84
S12	7.30	29.47	10.41	28.83	31.30
S13	7.58	29.76	10.00	24.91	31.06
S14	7.62	29.70	7.00	20.99	27.12
S15	7.42	29.66	6.00	17.99	25.93

From the study, the oxygen demand for the Integrated Phytogreen System gradually decreased for both BOD and COD, the amount of chemical substances, bacteria, organic matters decreased throughout the system. Organic matter which were being decomposed by the microorganisms with the aid of oxygen, took up as many as oxygen needed to decompose the matter.

Suspended solids were caused by non-dissolved matters, dried leaves, roots and pollen reduced through the system. In the aeration, the suspended solids were slightly high as the turbulence from the aerator. The suspended solids were then filtered by the clarifier and the sludge enclosed flowed back to the aeration zone as Return Activated Sludge. The overall process produced Standard A wastewater quality for Suspended Solids.

Aeration process has been able to increase the oxygen content by 54% in this study. This showed that the aeration part is crucial for supplying enough oxygen for oxidizing, respiration and also reacting toward specific matter.

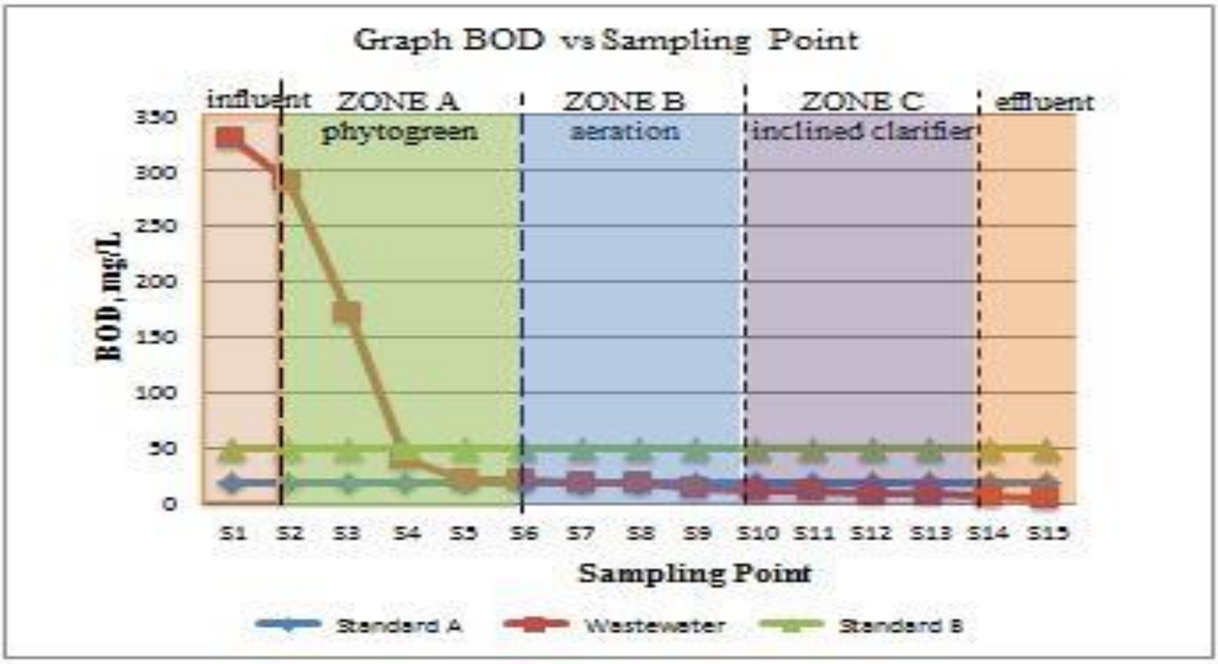

Fig. 2: Graph BOD against Sampling Point.

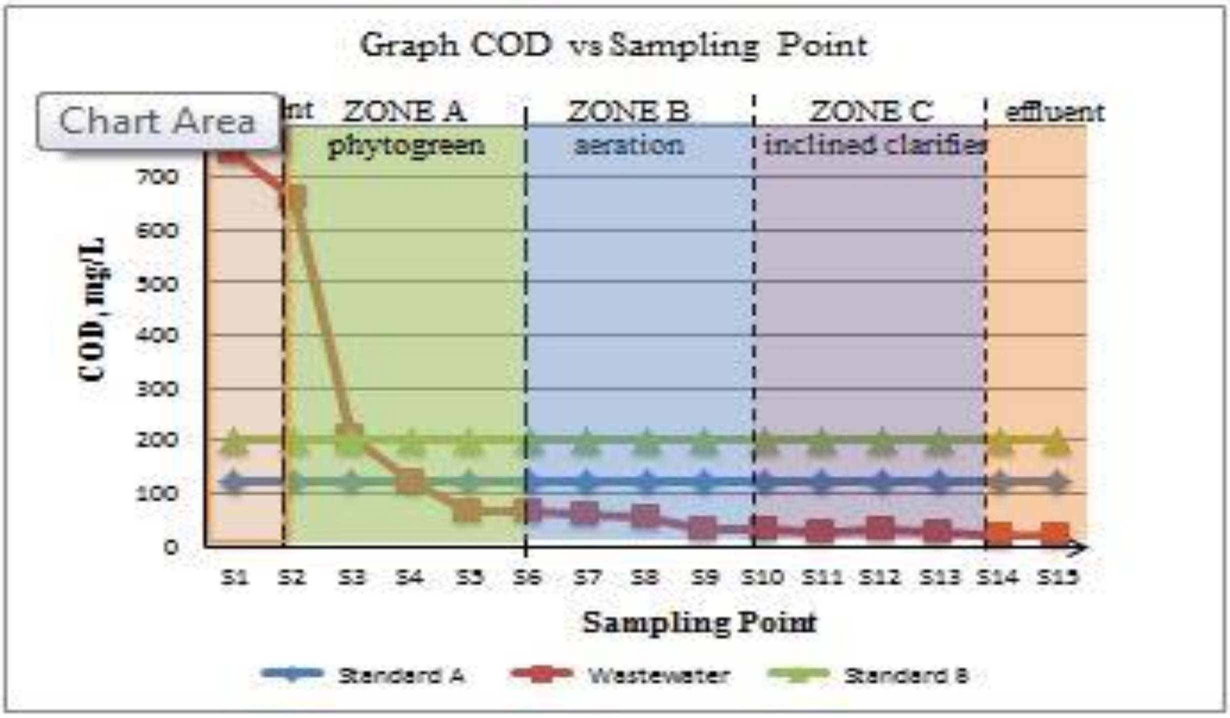

Fig. 3: Graph COD against Sampling Point.

Fig 4 and Fig 5 shows that Aeration zone has succeeded in lowering the value of Chemical Oxygen Demand and Biochemical Oxygen Demand. Aeration zone has lowered 97% of BOD and 96% of COD in this study. The overall removal efficiency for BOD and COD are 98.1% and 97.6% respectively.

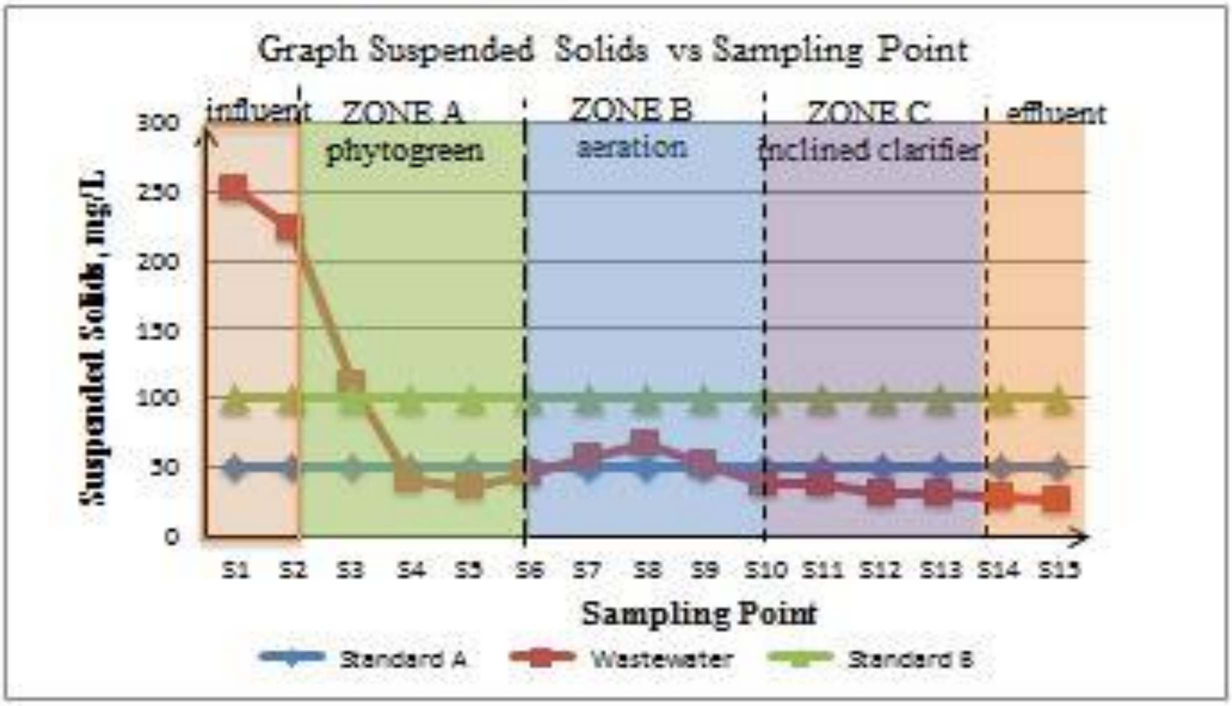

Fig. 4: Graph SS against Sampling Point.

Suspended Solids has been decreased for 85% through the aeration zone, and 90% after the overall process. The concentration of suspended solids in this integrated system was in Standard A .

For comparison of means, the data were examined statistically using one-way ANOVA followed by Duncan multiple comparison test with p is less than 0.05, $p<0.05$ (SAS, 1999). The first step to solve ANOVA problem would be to state the null (H_0) and alternative (H) hypothesis. In this test, the H_0: $\mu_1 = \mu_2 = \mu_3 = \ldots = \mu_{15}$ which means that there is no significant changes or the values are the same. The alternatives hypothesis, H_1: $\mu_i \neq \mu_j$ for $i \neq j$ means that there are differences in the data and the treatment is affected. The significant value for this test is 0.05. All the hypothesis involves can be defined as μ_1 is equal to the mean of parameter content in the influent part of wastewater. μ_{15} is the mean of parameter content in the effluent part of wastewater.

Conclusions

Phytoremediation is a fast developing field. Since the last ten years, a lot of field applications have been initiated all over the world, including phytoremediation of organic, inorganic and radionuclides. This sustainable and emerging technology is seen as a viable alternative to conventional remediation methods. This technology is suitably apprehended by developing countries. The phytogreen system is one of the systems that make up phytoremediation. Aeration process is added into this system as an integrated system to enhance the quality of wastewater.

Based on the overall results obtained, the study found that there were various factors that contribute the success of the aeration zone in the system and also the failure in enhancement of the system. Thus, based on the results and discussions that have been made, it could be concluded that; The integrated system has proven the ability to produce Standard A discharge water in this study. This gives hope for the better chance on reviving the river pollution and improving the drinking water quality. The environmental friendly treatment used in this study might be the answer for the better future

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References

Abdel-Raouf, N., A Al-Homaidan, A., and Ibraheem, I.B.M (2012), "*Microalgae and wastewater treatment*", Saudi Journal of Biological Sciences.

Abdul Syukor A.R., A.W. Zularisam, Z. Ideris, M.I. Mohd. Said, S. Sulaiman (2013a). "Treatment of Industrial Wastewater At Gebeng Area Using *Eichornia Crassipes Sp* . (Water Hyacinth) , *Pistia Stratiotes* Sp . (Water Lettuce) and Salvinia Molesta Sp . (Giant Salvinia)," *Adv. Environ. Biol.*, vol. 7, no. October Special Issue 2013, pp. 3802–3807.

A. Syukor, A. Wahid, I. Zakaria, M. Ismid, S. Sulaiman, A. Halim, and D. L. Thomas (2013). *Potential of Aquatic Plant as Phytoremediator for Treatment of Petrochemical Wastewater in Gebeng Area , Kuantan*. Adv. Environ. Biol., vol. 7, pp. 3808–3814.

Abdul Syukor bin Abd Razak and Suryati, Sulaiman (2014a). "*Treatment Of Industrial Wastewater Using Eichornia Crassipes, Pistia Stratiotes and Salvinia Molesta In Phytogreen System*", Energy Education Science and Technology Part a Energy Science and Research, 32 (1). 339-346 . ISSN 1308-772X.

Abdul Syukor bin Abd. Razak, Zularisam bin Ab Wahid, Ideris bin Zakaria, Mohd. Ismid bin Mohd. Said, Suryati bt. Sulaiman (2014b). "*Treatment of industrial wastewater in Gebeng Area, Kuantan Pahang using Phytogreen System"*. Energy Education Science and Technology Part a Energy Science and Research, 32 (1) **:** 347-354 . ISSN 1308-772X.

A.R. Abdul Syukor, A.W. Zularisam, Z. Ideris, M.S. Mohd Ismid, H.M. Nakmal, S. Sulaiman, A.H. Hasmanie, M.R. Siti Norsita, M. Nasrullah. *Performance of Phytogreen Zone for BOD_5 and SS Removal for Refurbishment Conventional Oxidation Pond in an Integrated Phytogreen System*. International Journal of Environmental, Earth Science and Engineering Vol:8 No:3, 2014

APHA, AWWA, WPCF, (1998). Standard Methods for the Examination of Water and Wastewater, 20th ed. American Public Health Association, Washington, DC

Burkhead C E & O'Brien W J. (1974). *Journal - Water Pollution Control Federation 07/1974*; 46(6):1135-40.

Divya Singh, Archana Tiwari and Richa Gupta, "*Phytoremediation of lead from wastewater using aquatic plants*", School of Biotechnology, Rajiv Gandhi Proudyogiki Vishwavidyalaya Airport bypass road, Gandhi Nagar, Bhopal, Madhya Pradesh, India (2012)

GE Power & Water (Water & Process Technologies), "*Chapter 37 – Wastewater Treatment*", http://www.gewater.com/handbook/wastewater_gas_cleaning_systems, 2012.

Ghosh M and Singh S.P. 2005. *A Review on Phytoremediation of Heavy Metals and Utilization of its Byproducts*. 1-18

National Service Center for Environmental Publications (NSCEP), "*Principles of Design and Operations of Wastewater Treatment Pond Systems for Plant Operators, Engineers and Managers"*, August 2011.

Nyer, Evan K., "*Groundwater Treatment Technology*", John Wiley & Sons, 15 May 1992

Rajiv K. Sinha, Dalsukh Valani , Shanu Sinha, Shweta Singh & Sunil Heart, "*bioremediation of contaminated sites: Low-cost nature's biotechnology for Environmental clean up by versatile Microbes, plants & earthworms,* © 2009 Nova Science Publishers, Inc.

Water Resources Management And Hydrology Division, Department Of Irrigation and Drainage, Ministry Of Natural Resources And Environment, Malaysia; Study On The River Water Quality Trends And Indexes In Peninsular Malaysia 2009

Water Encyclopaedia; Science & Issues, "*Lakes: Chemical Processes",* http://www.waterencyclopedia.com/Hy-La/Lakes-Chemical-Processes.html, 2015