

Ultra -Violet Disinfection and Logarithmic Modeling of Pathogenic *Giardia lamblia* in Aqueous Suspension.

Benjamin Abu. E^{1*}, Olabimtan Olabode.H², Aronimo Samuel .B³, Akinlotan Oluyinka.O⁴ & Onyike Onyinyechi.G⁵

^{1,5}University of Jos, Faculty of Natural Science, Department of Chemistry, Jos Plateau State, Nigeria.

²National Research Institute for Chemical Technology, Department of Industrial and Environmental Pollution, Zaria Kaduna State, Nigeria.

^{3,4}Kogi State College of Education (Technical), Department of Chemistry, Kabba, Kogi state, Nigeria.

Corresponding email: Olabode4angel@gmail.com

Abstract: Pathogenic *Giardia of lamblia species* is a devastating waterborne agent to public health since their cysts are persistently ubiquitous in water (wastewater) and insensitivity to physical-chemical water treatment processes. Technically, the documented performance of UV radiation against the cells of various pathogenic microorganisms encourages the reactivity of *G. lamblia* in solution with 254nm wavelength of monochromatic UV light at any significant concentration was computed with Plutocalc water calculator. The systematic deactivations of *G. lamblia* in solution were captured with twenty-one points of UV dose from $(16 \times 10^{-4}) \mu\text{Ws.cm}^2$ to $(248 \times 10^{-4}) \mu\text{Ws.cm}^2$, % removal from 74.9% to 100% and contact time of 60 to 1,260 seconds at an ambient temperature of 25°C. Two logarithmic models were established between the percentage treatment (%T) and UV dose (UV) as $\%T = 5.187 \ln(\text{UV}) + 74.39$ ($R^2 = 0.5470$); and between the same percentage treatment and the contact time (CT) of UV the radiation as $\%T = 6.986 \ln(\text{CT}) + 52.73$ ($R^2 = 0.8380$). Therefore, the UV disinfection method at practical doses can achieve appreciable and significant treatment of *G.lamblia* on the water without infectivity reactivation.

Keywords: *Giardia lamblia*, monochromatic UV-irradiation, percentage treatment removal, logarithmic models and contact time.

1.0 INTRODUCTION

Giardia lamblia is perhaps of the significant waterborne pathogenic microorganisms of relationship with various waterborne health challenges through potable water supplies even with fulfilled administrative guidelines for turbidity and coliforms indices [1]. *G. lamblia* cysts are reliably active at the concentration of 102 and 104/L in waste and polluted water [2], exceptionally pervasive in surface source waters, [3], and generally impervious to traditional water and wastewater treatment measures, including chemical sterilization [4]. A suitably operated filtration method accomplishes some actual expulsion of this microorganism growth almost about 99-99.9%, and however, most compound sanitization measures accomplish just modest inactivation of *G. lamblia* at pragmatic dosages and contact times [5]. Based on the in vitro feasibility measures of excystation and fundamental color staining, Rice and Hoff revealed that cysts of *G. lamblia* are likewise exceptionally resistant to UV light [6]. Craik et al., utilizing an in vivo laboratory mouse infectivity examination, revealed that polychromatic UV radiation from medium-pressure (MP) UV mercury lights widely inactivates *Giardiamuris* growths at moderately low UV dosages [7]. In any case, most drinking water and wastewater therapy plants have been applying UV monochromatic radiation at low pressing factor (LP) for sanitization. Along these lines, the degree of UV inactivation of the human microorganism *G. lamblia* as estimated by a laboratory organism infectivity test has not been accounted for. Notwithstanding a requirement for assessing the impact of UV illumination on *G. lamblia* infectivity, the ability of this parasite to fix UV-interceded

DNA injury and reestablish infectivity likewise requires examination. Information on DNA fix ability will help in the appropriate plan of UV sanitization frameworks to accomplish protozoan inactivation. Numerous creatures can fix DNA sores brought about by exogenous UV radiation, ionizing radiation, and synthetic compounds or endogenous components [8]. Notably, a portion of these pathogenic microorganisms has at least one of these regulatory pathways technically as photoreactivation [9], [10]. Nonetheless, it was as of late revealed that UV-inactivated *Cryptosporidium parvum* did not show transformation with the infectivity of the cell culture through the dual conditions of light [11]. However, it is not understood whether the cysts of *G. lamblia* have DNA secure pathways that will restore the infectivity and the defects by UV irradiation light [12]. Meanwhile, the UV dosages, treatment logs (percentage), and the contact time required to significantly disinfect *G.lamblia* in a water solution at ambient conditions were mathematically represented

2.0 METHODOLOGY

2.1 *G. lamblia* cyst isolation [13], UV disinfection procedure of *G.lamblia* in water [14] and water quality analyses [15] can be evaluated accordingly.

2.2 UV water treatment set up

The agency's (EPA) ultraviolet disinfection guidance online manual (LT 2ESWTR, 2006) was electronically simulated and computed with the least log removal of $\log_{10}0.20$ (74.9 %) at an advancing UV exposure period of 60 seconds till $\log_{10} 4.4$. (100% removal treatment)[16].

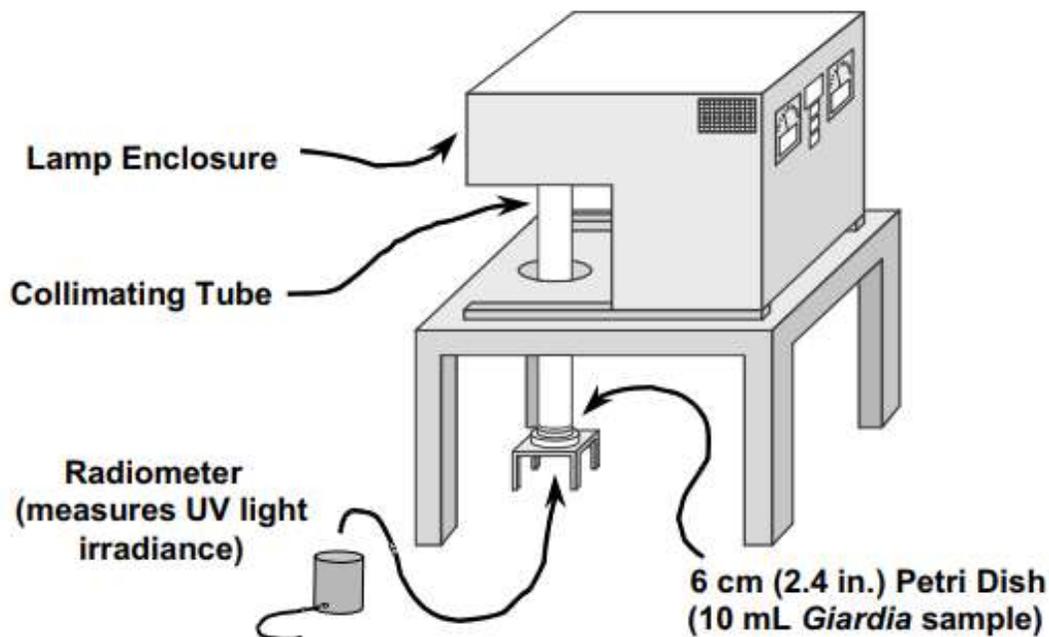


Figure 1. Experimental set up of UV inactivation of *G.lamblia* in water [17].

3.0 RESULTS AND DISCUSSION

Table 1 Ultra-Violet computational disinfection of *G. lamblia* in water.

UV dose (X 10 ⁻⁴) ($\mu\text{W.s/cm}^2$)	Log removal	% removal	Contact time (seconds)
16.00	0.60	74.90	60
18.60	0.80	84.20	120
21.00	1.00	90.00	180
24.60	1.20	93.70	240
28.20	1.40	96.20	300
34.40	1.60	97.50	360
43.20	1.80	98.40	420
52.00	2.00	99.00	540
62.00	2.20	99.40	600
72.00	2.40	99.60	660
83.60	2.60	99.80	720
96.80	2.80	99.84	780
110.00	3.00	99.90	840
126.00	3.20	99.94	900
142.00	3.40	99.96	960
164.00	3.60	99.98	1020
192.00	3.80	99.98	1080
220.00	4.00	99.99	1140
220.00	4.20	99.99	1200
248.00	4.40	100.00	1260
248.00	4.40	100.00	1320

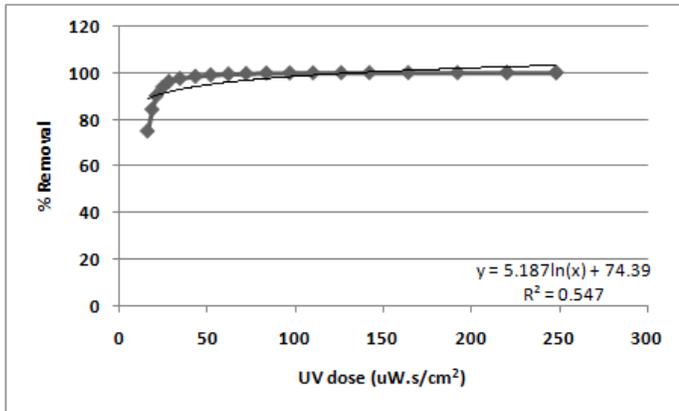


Figure 2. Plot of the percentage treatment with the UV radiation dose

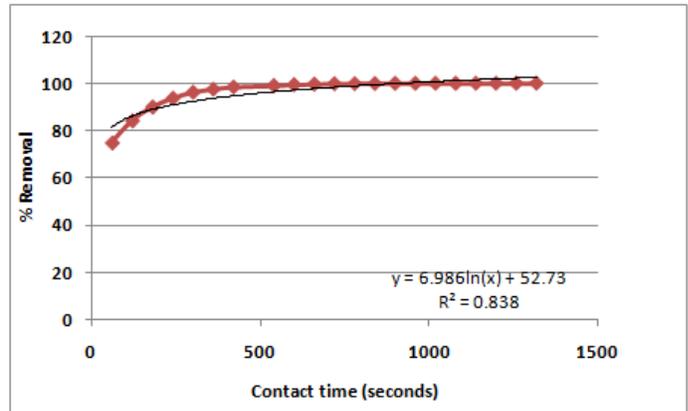


Figure 3. Plot of the percentage treatment against time in seconds

As indicated in figure 1, the cysts contaminated water suspensions will be presented to different degrees of UV light from a low-pressure UV light in a collimated-pillar unit. The low-pressure UV light will be mounted over within some widths of polyvinyl chloride (PVC) collimating tube. The transmission of stray mirrored light through the cylinder will be limited by covering the inside of the cylinder with level dark paint. A pneumatically programmed shade should be situated between the light and the collimating tube with an opening/shutting time. These collimated-pillar tests uncovered consistently blended suspensions of Giardia in ordinary 0.5cm (0.2in), 10mL volumes contained in a 60mm (2.4in) sterile Permanox tissue culture dish with the progress of time. The collimating tube which normally is 127 cm (50 in.) long reliably gave an applied UV irradiance opposite to the suspension degree of irradiance estimated by the radiometer.

The portion of UV light applied to the inhibition of Giardia was determined by estimating the UV light net irradiance with the sample's complete exposure. The resultant effects were then favorable to the evaluation across the water surface irradiance appropriately at the initial point. In confirming the range in magnitude of this radiation across the water surface, UV irradiance will be estimated once toward the start of the investigation through a 0.5cm (0.2in) planar network across 25 levels. Also, before figuring a modulated UV portion, the resultant values by the radiometer readings were altered by absorbance of the regular water condition before Giardia suspension as justified by Beer-Lambert Law. Then, UV irradiance was then amplified by the time of exposure in deciding the respective fraction of UV light, estimated in mJ/cm² [18].

Table 2. UV treatment models of G.lamblia

Interaction	Model Identity	Model Equation	Regression coefficient (R ²)
% Treatment (%T) Vs UV dose (μW.s/cm ²)	Logarithmic	%T = 5.187 ln (UV dose) + 74.39	0.5470
% Treatment (%T) Vs Contact time (secs.)	Logarithmic	%T = 6.986 ln (CT) + 52.73	0.8380

The outcomes generated (Table 1), were in terms of the UV intensities as doses, the treatment logs (% removal), and the contact or reaction time in seconds. Therefore the plots in Figures 2 and 3 declared some definite logarithm functions with the relationship between the percentage treatments, UV doses, and the contact time with the G.lamblia in solution (Table 2). These show that the mechanism of the UV water treatment is principally the function of the pathogenic concentrations.

3.0 CONCLUSION

A computational approach has been adopted in the treatment of water and deactivation of a pathogenic gladia lamblia in solution. It has demonstrated some acute sensitivities to low dosages of UV light as from (16 X 10⁻⁴) μW.s/cm² with the treatment percentage of 74.9 % under 60 seconds and (248 X 10⁻⁴)μW.s/cm² at 100% treatment level over 1,260 seconds. Apparently, as G. lamblia retains zero or less resistance to

UV light, future UV disinfection research could be conducted with more accurate computational models in order to obtain further conditional measures for the deactivation of *G. lamblia* in water systems chemically, biologically and physiologically.

4.0 REFERENCES

1. Nygård, K. et al (2006). A large community outbreak of waterborne giardiasis - delayed detection in a non-endemic urban area. *BMC Public Health* **6**, 141 (2006). <https://doi.org/10.1186/1471-2458-6-141>
2. Dong Li et al (2009). Infectivity of *Giardia lamblia* cysts obtained from wastewater treated with ultraviolet light. *Water Research*. Volume 43, Issue 12, 2009, Pages 3037-3046, ISSN 0043-1354, <https://doi.org/10.1016/j.watres.2009.04.024>.
3. Kerry A. Hamilton et al (2018). *Cryptosporidium* and *Giardia* in Wastewater and Surface Water Environments. *Journal of Environmental Quality* **47**(5).10.2134/jeq2018.04.0132
4. G-A Shin et al (2009). Inactivation of *Giardia lamblia* cysts by polychromatic UV. *Letters in Applied Microbiology* **48**(6):790-2.10.1111/j.1472-765X.2009.02597.x
5. AG-Metal Zenica (2011). Treatment operation of water and unit process. / *Operac. Tret. Vode*. <https://issuu.com/ag-metal/docs/22573343-water-treatment-operations-and-unit-proce>
6. Andrew T Campbell and Peter Wallis (2002). The effect of UV irradiation on human-derived *Giardia lamblia* cysts. *Water Research* **36**(4):963-9.10.1016/S0043-1354(01)00309-8
7. Soo-Ung Lee et al (2008). Pulsed-UV Light Inactivation of *Cryptosporidium Parvum*. *Parasitological Research* **102**(6):1293-9.10.1007/s00436-008-0908-5
8. Ana L Santos et al (2012). Wavelength dependence of biological damage induced by UV radiation on bacteria. *Archives of Microbiology* **195**(1).10.1007/s00203-012-0847-5
9. Ahmed, H. (2016). Review of Medical Microbiology and Immunology Fourteenth Edition. https://www.academia.edu/43728878/Review_of_Medical_Microbiology_and_Immunology_Fourteenth_Edition
10. Milad Raeiszadeh and Fariborz Taghipour (2020). Inactivation of microorganisms by newly emerged micro plasma UV lamps. *Chemical Engineering Journal*.10.1016/j.cej.2020.127490
11. Burhan Adhami et al (2007). Detection of UV-Induced Thymine Dimers in Individual *Cryptosporidium parvum* and *Cryptosporidium hominis* Oocysts by Immunofluorescence Microscopy. *Applied and Environmental Microbiology* **73**(3):947-55.10.1128/AEM.01251-06.PubMed
12. Dong Li et al (2008). Survival of *Giardia lamblia* trophozoites after exposure to UV light. *FEMS Microbiology Letters* **278**(1):56-61.10.1111/j.1574-6968.2007.00972.x
13. Agostinho Cruz et al (2003). Isolation, excystation and axenization of *Giardia lamblia* isolates: In vitro susceptibility to metronidazole and albendazole. *Journal of Antimicrobial Chemotherapy* **51**(4):1017-20.10.1093/jac/dkg150.PubMed
14. Karl G Linden et al (2002). UV Disinfection of *Giardia lamblia* Cysts in Water. *Environmental Science and Technology* **36**(11):2519-22.10.1021/es0113403
15. HP Technical assistance hydrology project (1999). Standard Analytical Procedures for Water Analysis <http://indiawrm.org/Website/Webpages/PDF/download-manuals-WaterQuality-TechnicalPapers-StandardAnaly.pdf>
16. www.danbp.org. D. (2021). Plutocalc Engineering Software. <https://www.plutocalc.com/>
17. A.A. Mofidi et al (2002). The effect of UV light on the inactivation of *Giardia lamblia* and *Giardia muris* cysts as determined by animal infectivity assay (P-2951-01). *Water Research* **36** (2002) 2098-2108. www.elsevier.com/locate/waters.
18. MOROWITZ HJ. Absorption effects in volume irradiation of microorganisms. *Science*. 1950 Mar 3; **111**(2879):229. Doi: 10.1126/science.111.2879.229-a. PMID: 15410099.