Journal of Science & Multidisciplinary Research Vol. 1(2), pp1-7, December 2012

Available online http://www.irjset.com

IRJSET

Inhibitory Effects Of Nicotine On Corrosion Caused By *Desulphovibrio* Sp. Isolated From Water Pipes in Minna, Nigeria

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Abstract The inhibitory effects of nicotine on corrosion caused by *Desulphovibrio* sp. isolated from water pipes in Minna, Nigeria was carried out. Nicotine was extracted from cigarette and tobacco leaf using soxhlet extractor. Pure culture of the test organism was inoculated into Postgate medium containing water pipes, with nicotine concentrations of 10mg/ml, 50mg/ml, 200mg/ml, 300mg/ml, 400mg/ml and 500mg/ml. A control was set up (without nicotine) and the culture was incubated anaerobically for 30days. The rate of corrosion was determined by weight loss method. For nicotine extracted from cigarette, the average % weight loss at concentrations of 10mg/ml, 50mg/ml, 200mg/ml, 300mg/ml, 400mg/ml, 500mg/ml and control (0mg/ml nicotine) were 3.10%, 1.7%, 1.74%, 1.08%, 1.44%, 0.31% and 6.57% respectively while for nicotine extracted from tobacco leaf, the average % weight loss at concentrations of 10mg/ml, 50mg/ml, 200mg/ml, 300mg/ml, 400mg/ml, 500mg/ml and control (0mg/ml nicotine) were 3.44%, 3.11%, 1.54%, 0.73%, 0.85%, 0.13% and 5.57% respectively. At 50mg/ml, 200mg/ml, 300mg/ml, 400mg/ml, 500mg/ml concentration, there were significant differences ($P<0.05$) between the % weight loss of the various concentration of nicotine extracted from cigarette and tobacco leaf between the 4th and 30th day incubation period but there was no significant difference ($P>0.05$) at the second day incubation and at 0 and 10mg/ml concentration. The results of this study showed that higher concentrations of nicotine had varying inhibitory effect on the test organisms.

Keywords *Desulphovibrio* sp., corrosion, nicotine, tobacco leaf, cigarette

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Published online at http://www.irjset.com

1. Introduction

Corrosion is a naturally occurring phenomenon commonly defined as the deterioration of a metal or its properties or components because of its physicochemical interaction with the environment (Oyeleke *et al.*, 2005; Akpabio *et al.*, 2011). Microorganisms present in biofilms can cause and influence corrosion because of their ability to utilize these metals as a source of carbon and energy required for their growth and metabolism using products of their metabolic activities such as enzymes, exopolymers,

organic and inorganic acids, as well as ammonia and hydrogen sulphide, this leads to deterioration and failure of pipes (Oyewole *et al.*, 2011). The resulting metal deterioration is known as bio-corrosion or microbiologically influenced corrosion (MIC) (Beech and Gaylarde, 2008; Oyewole, 2011).

Bacteria are considered the primary colonizers of inanimate surfaces in both natural and man-made environments. Therefore, the majority of microbial influenced corrosion investigations tend to address the impact of pure and mixed cultured bacterial biofilms on corrosion behaviour of iron, copper, aluminum and their alloys (Beech and Sunner, 2004). Bacteria frequently implicated in corrosion of metallic piping are anaerobes that generate hydrogen sulphide, including sulphate reducing bacteria (SRB) e.g. *Desulphovibrio* sp., *Desulphotomaculum* sp. and *Desulphoromonas* sp. The microorganisms typically co-exist in a symbiotic relationship causing damage to steel pipes (Muyzer and Stams, 2008; Beech and Gaylarde, 2008; Kakooei *et al.*, 2012). Unfortunately, inspections for MIC is often overlooked. Bio-corrosion causes water pipelines to have a low mechanical strength in place thereby resulting in the perforation of the pipes as a result of pit formation. If this occurs in sewage drainage system, it may result into an influx of sewage water into the municipal water supplies thereby causing enormous health risks to human (Oyewole *et al.*, 2011).

Owing to the negative impacts of corrosion both on metals, pipelines and concretes and economical loses associated with this menace, there is an urgent need to examine various materials that have the ability to corrode. According to Rosa (2011), leaf and plant extracts are potential sources of novel corrosion inhibitors of metals. Fraunhofer (1996) examined anticorrosion effects of nicotine and Sangeetha *et al.* (2011) also reported the use of some plant extracts to inhibit corrosion of metals using electrochemical approach.

Nicotine is an alkoloid (a substance with a basic charge) contained in the leaves of several species of plants. The primary commercial source of nicotine is by extraction from the dried leaves of tobacco plant (*Nicotiana tabacum*). The chemical formula for nicotine is $C_{10}H_{14}N_2$, with a molecular mass of 162.23. In proper nomenclature, nicotine is 3-(1-Methyl-2-pyrrolidinyl) pyridine (Pugh, 2002; Howard, 2012).Currently, nicotine is a permitted pesticide for organic farming (Pottorff, 2010). It can also be used as anti-herbivore chemical (Rodgman and Perfetti, 2009, Howard, 2012) as well as an anti-corrosion agent (Streeter, 2010; Schwartz, 2010; Sangeetha *et al.*, 2011). This research therefore, is aimed at investigating the inhibitory effects of nicotine on corrosion influenced by *Desulphovibrio* sp. isolated from water pipes in Minna, Niger State using microbiological approach.

2. Materials and Methods

Samples collection

Tobacco plant was collected from plantation of the Federal University of Technology, Minna, Nigeria and cigarette was purchased from Minna markets. The samples were brought into the Microbiology Department laboratory of the Federal University of Technology, Minna, Nigeria.

Preparation of media

Postgate medium was used for the isolation of the test organism. It was compounded from its various ingredients (0.5g K_2HPO_4, 2g NaCl, 1g $NaSO_4$, 0.1g $CaCl_2$, 3.5g Sodium lactate,0.0002 $FeSO_4.7H_2O$, 1g yeast extract, 1litre distilled water) and sterilised at 121°C for 15-20 minutes.

Isolation of *Desulphovibrio* sp.

Desulphovibrio sp. was isolated from corroded water pipes in Minna, Nigeria. Samples of the corroded pipes was aseptically collected into a sterile McCartney bottles and brought into the microbiology department laboratory of Federal University of Technology, Minna, Nigeria. Five-fold serial dilution was carried out and was plated on freshly prepared Postgate agar and incubated anaerobically at 37°C for 3-5days. One millilitre (1ml) of the pure isolate was subcultured into 9ml of Postgate broth and incubated anaerobically at 37°C for 3-5days (Cheesbrough, 2003; Cowan and Steel, 1974).

Extraction of nicotine

Aqueous solution was used for the extraction of the nicotine from the tobacco plant leaf and cigarette. Two hundred gram (200g) of each pulverised samples was suspended in 1000ml of aqueous solution and extracted using Soxhlet extractor for 120hours. The extracts were decanted, filtered and evaporated in vacuole at 45°C.

Determination of corrosion effects of nicotine on the test organism

Nine millilitre (9ml) of Postgate broth was dispensed into 7 tubes and various concentrations of nicotine viz: 10mg/ml, 50mg/ml, 200mg/ml, 300mg/ml, 400mg/ml, 500mg/ml was introduced into each tube, a control was also set up, without nicotine (0mg/ml). Ten gram (10g) of clean water pipe was introduced into each tube containing various concentrations of the nicotine and the control. The medium was sterilised using autoclave at 121°C for 15-20 minutes . One millilitre (1ml) of the pure isolate was inoculated into each tube and the experiment was set up for 30days. Rate of corrosion was determined using weight loss method.

Statistical analysis of data

Results obtained from this research was subjected to statistical analysis using ANOVA and MINITAB 14 at 95% confidence limit.

3. Results

Fig. 1 shows the effects of nicotine extracted from cigarette on corrosion caused by *Desulphovibrio* sp. within 30days incubation period. At nicotine concentration of 500mg/ml, 400mg/ml, 300mg/ml, 200mg/ml, 50mg/ml, 10mg/ml, the average weight loss were 0.39%., 1.64%, 1.10%, 1.78%, 1.75%, 3.23% respectively. However, the percentage weight loss of the control (concentration of 0mg/ml), ranged from 0-7.51% with an average of 6.16% after 30days incubation period.

Fig. 2 shows the effects of nicotine extracted from tobacco leaf on corrosion caused by *Desulphovibrio* sp. At 500mg/ml, the average weight loss was 0.15% after 30days incubation period. The percentage weight loss at 400mg/ml concentration, ranged from 0-1.37% with an average of 0.88%. At 300mg/ml, the percentage weight loss ranged from 0-1.07%. At concentration of 200mg/ml and 50mg/ml, the percentage weight loss were 1.60% and 3.22% respectively while the percentage weight loss for the control (at concentration of 0mg/ml), was 6.17%.

Table 1 shows the result of nicotine extracted from cigarette and tobacco leaf on *Desulphovibrio* sp. At 0 mg/ml and 10mg/ml concentration, there were no significant differences ($P>0.05$) between percentage weight loss of nicotine from cigarette and tobacco. However, there were significant differences ($P<0.05$) between the two extracts at 50mg/ml, 200mg/ml, 300mg/ml, 400mg/ml and 500mg/ml. From Table 2 and Table 3, there was an inverse relationship between the weight loss/day for nicotine extracted from cigarette and tobacco leaf. Hence the higher the concentration, the lower the weight loss/day for nicotine extracted from cigarette and tobacco leaf.

4. Discussion

This research focused on investigating the inhibitory effects of nicotine on corrosion activities caused by *Desulphovibrio* sp. *Desulphovibrio* sp. is a leading sulphate reducing bacterium involved in microbiologically influenced corrosion. Its mechanism of corrosion is by reducing oxidized sulphur to reduced sulphur compound. The sulphide thus formed, reacts with iron (Fe) in pipes to form FeS- a corrosion product (Beech and Sunner, 2004, Beech and Gaylarde, 2008, Oyeleke *et al.*, 2005, Oyewole, 2011, Oyewole *et al.*, 2011, Kakooei *et al.*, 2012). Various concentrations of nicotine examined (10mg/ml, 50mg/ml, 200mg/ml, 300mg/ml, 400mg/ml and 500mg/ml) have varying inhibitory effects on corrosion activities by *Desulphovibrio* sp. compared with the control (Fig. 1 and Fig. 2). The nicotine may form a barrier layer on the water pipes preventing the utilization of the pipes and subsequent formation of the corrosion products. The higher the concentration of the nicotine, the more the inhibitory effects was observed (Fig 1 and Fig 2). This was more evident in Table 2 and Table 3, which shows that the decrease in weight loss/day is caused by an increased concentration of nicotine (negative correlation). At higher concentration values examined (200mg/ml and 500mg/ml), a significantly higher inhibitory effects of nicotine extracted from cigarette on the test organisms was observed when compared to the nicotine from tobacco leaf but at 0, 10 and 50 mg/ml concentrations the reverse was observed.

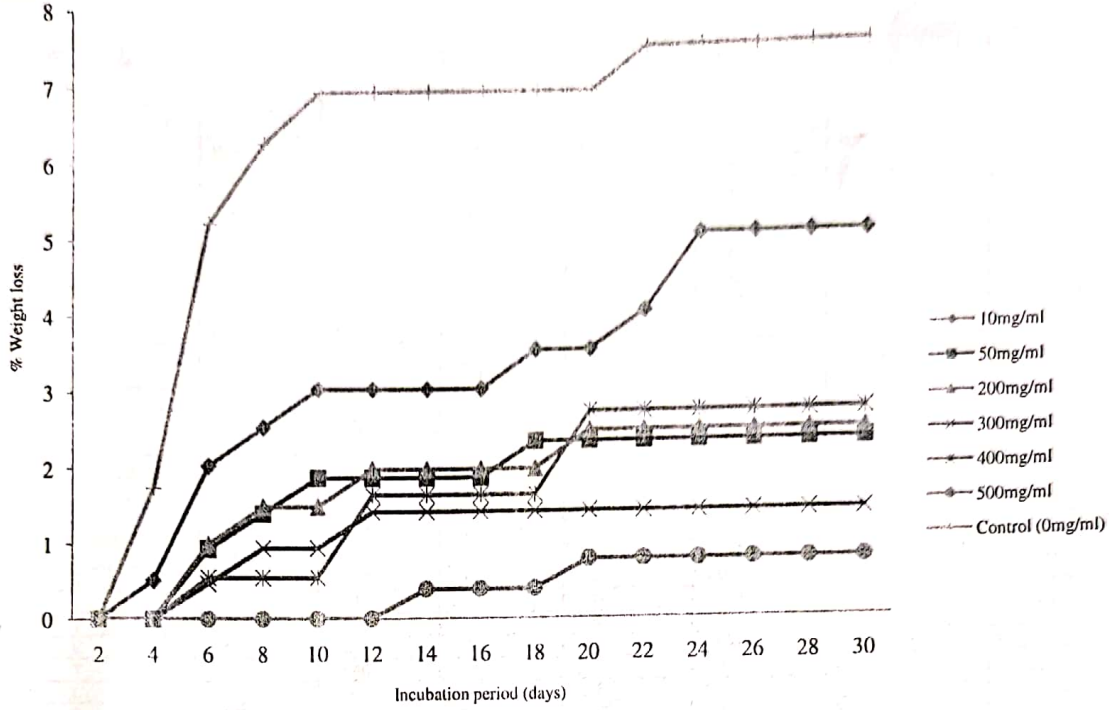

Fig. 1. Effects of nicotine extracted from cigarrete on corrosion caused by *Desulphovibrio* sp.

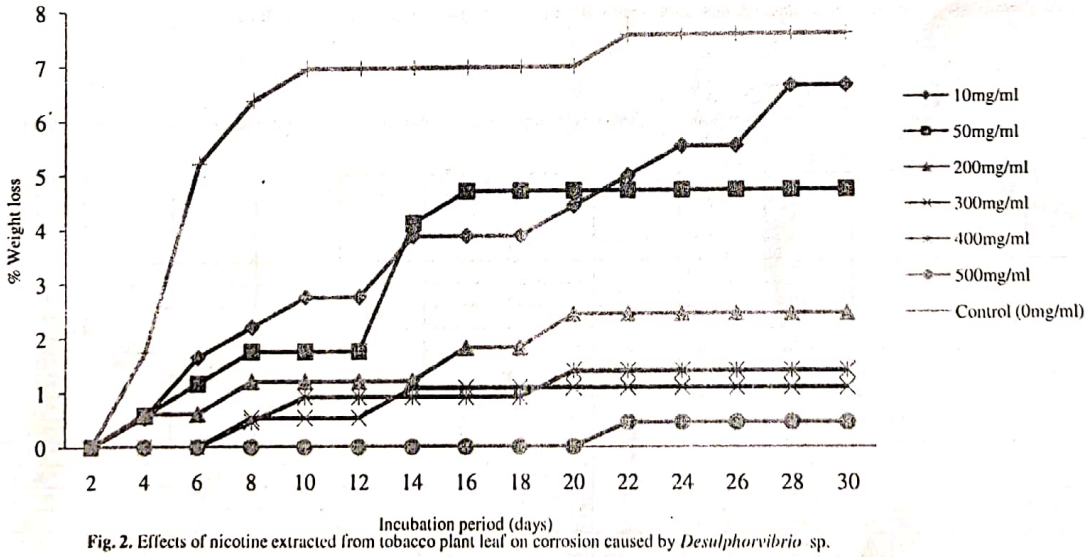

Fig. 2. Effects of nicotine extracted from tobacco plant leaf on corrosion caused by *Desulphorvibrio* sp.

Table 1. Corrosion inhibitory effects of nicotine extracted from cigarette and tobacco Leaf on *Desulphovibrio* sp.

Concentration Mg/ml / No. of days		0	10	50	200	300	400	500
2	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	T	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	C	1.73^{a}	0.51^{b}	0.00	0.00	0.00	0.00	0.00
	T	1.73^{a}	0.55^{b}	$*0.58^{b}$	0.51^{b}	0.00	0.00	0.00
6	C	5.20^{a}	$*2.02^{b}$	$*0.93^{c}$	$*0.99^{c}$	$*0.47^{d}$	$*0.55^{d}$	0.00^{e}
	T	5.27^{a}	1.64^{b}	1.16^{c}	0.61^{d}	0.00^{e}	0.00^{e}	0.00^{e}
8	C	6.26^{a}	$*2.53^{b}$	1.40^{c}	$*1.49^{c}$	$*0.94^{d}$	$*0.55^{e}$	0.00^{f}
	T	6.36^{a}	2.19^{b}	$*1.74^{c}$	1.20^{d}	0.53^{e}	0.46^{e}	0.00^{f}
10	C	6.94^{a}	$*3.03^{b}$	1.87^{c}	$*1.49^{d}$	$*0.93^{e}$	0.55^{f}	0.00^{g}
	T	6.94^{a}	2.73^{b}	1.73^{c}	1.20^{d}	0.53^{e}	$*0.91^{f}$	0.00^{g}
12	C	6.94^{a}	$*3.03^{b}$	1.87^{c}	$*1.98^{d}$	$*1.42^{e}$	$*1.64^{f}$	0.00^{g}
	T	6.94^{a}	2.73^{b}	1.73^{c}	1.20^{d}	0.53^{e}	0.91^{f}	0.00^{g}
14	C	6.94^{a}	$*3.03^{b}$	1.87^{c}	$*1.98^{d}$	$*1.42^{e}$	$*1.64^{f}$	0.00^{g}
	T	6.94^{a}	3.83^{b}	$*4.07^{c}$	1.20^{d}	1.07^{e}	0.91^{f}	0.00^{g}
16	C	6.94^{a}	3.03^{b}	1.87^{c}	$*1.98^{d}$	$*1.42^{e}$	$*1.64^{f}$	0.39^{g}
	T	6.94^{a}	$*3.83^{b}$	$*4.65^{c}$	1.44^{d}	1.07^{e}	0.91^{f}	0.00^{g}
18	C	6.95^{a}	3.54^{b}	2.34^{c}	$*1.98^{d}$	$*1.42^{e}$	$*1.64^{f}$	$*0.39^{g}$
	T	6.94^{a}	$*3.83^{b}$	$*4.65^{c}$	1.80^{d}	1.07^{e}	0.91^{f}	0.00^{g}
20	C	6.95^{a}	3.54^{b}	2.34^{c}	2.48^{d}	$*1.42^{e}$	$*2.73^{f}$	0.39^{g}
	T	6.94^{a}	$*4.37^{b}$	$*4.65^{b}$	2.40^{c}	1.07^{d}	1.37^{d}	0.00^{g}
22	C	7.51^{a}	4.01^{b}	2.34^{d}	2.48^{d}	$*1.42^{e}$	$*2.73^{c}$	$*0.78^{f}$
	T	7.51^{a}	$*4.92^{b}$	$*4.65^{b}$	2.40^{c}	1.07^{d}	1.37^{d}	0.44^{e}
24	C	7.51^{a}	5.05^{b}	2.34^{d}	2.48^{cd}	$*1.41^{e}$	$*2.73^{c}$	$*0.78^{f}$
	T	7.51^{a}	$*5.46^{b}$	$*4.65^{c}$	2.40^{d}	1.07^{ef}	1.37^{e}	0.44^{f}
26	C	7.51^{a}	5.05^{b}	2.34^{d}	2.48^{cd}	$*1.41^{e}$	$*2.73^{c}$	$*0.78^{f}$
	T	7.51^{a}	$*5.46^{b}$	$*4.65^{c}$	2.40^{d}	1.07^{ef}	1.37^{e}	0.44^{f}
28	C	7.51^{a}	5.05^{b}	2.34^{d}	2.48^{cd}	$*1.41^{e}$	$*2.73^{c}$	$*0.78^{f}$
	T	7.51^{a}	$*5.46^{b}$	$*4.65^{c}$	2.40^{d}	1.07^{ef}	1.37^{e}	0.44^{f}
30	C	7.51^{a}	5.05^{b}	2.34^{d}	2.48^{cd}	$*1.41^{e}$	$*2.73^{c}$	$*0.78^{f}$
	T	7.51^{a}	$*6.26^{b}$	$*4.65^{c}$	2.40^{d}	1.07^{e}	1.37^{e}	0.44^{f}

Key: C: Nicotine extracted from Cigarette, T: Nicotine extracted from tobacco leaf

*Within the same day, on the same column value at significantly higher than the other ($p<0.05$)

Value on the same row with different superscript are significantly different ($p\leq0.05$) while those with the same superscript are not significantly different ($p>0.05$)

Table 2. Relationship between concentration of nicotine extracted from cigarette and the days of incubation

Wt loss, no of Days	Conc mg/ml													
2	0													
4	-0.770*													
6	-0.715*	0.977*												
8	-0.740*	0.978*	0.966*											
10	-0.732*	0.964*	0.992*	0.995*										
12	-0.732*	0.964*	0.992*	0.995*	1.000*									
14	-0.880*	0.924*	0.929*	0.936*	0.933*	0.933*								
16	-0.894*	0.913*	0.904*	0.913*	0.905*	0.905*	0.995*							
18	-0.906*	0.925*	0.907*	0.917*	0.907*	0.907*	0.993*	0.998*						
20	-0.926*	0.917*	0.893*	0.909*	0.903*	0.903*	0.982*	0.984*	0.991*					
22	-0.919*	0.922*	0.901*	0.912*	0.911*	0.911*	0.979*	0.977*	0.982*	0.990*				
24	-0.916*	0.908*	0.895*	0.901*	0.902*	0.902*	0.972*	0.967*	0.971*	0.982*	0.996*			
26	-0.916*	0.908*	0.895*	0.901*	0.902*	0.902*	0.972*	0.967*	0.971*	0.982*	0.996*	1.000*		
28	-0.923*	0.873*	0.873*	0.865*	0.870*	0.877*	0.877*	0.953*	0.945*	0.949*	0.965*	0.983*	0.995*	
30	-0.923*	0.873*	0.873*	0.865*	0.870*	0.877*	0.877*	0.953*	0.945*	0.949*	0.965*	0.983*	0.995*	0.995*

*Correlation is significant at 0.01 level ($P<0.05$)

Table 3. Relationship between concentration of nicotine extracts from tobacco leaf and the days of incubation

Wt loss/No of Days	Conc mg/ml													
2	0													
4	-0.594*													
6	-0.706*	0.982*												
8	-0.742*	0.970*	0.996*											
10	-0.775*	0.964*	0.993*	0.997*										
12	-0.733*	0.953*	0.989*	0.989*	0.985*									
14	-0.733*	0.953*	0.989*	0.989*	0.989*	0.985*								
16	-0.712*	0.968*	0.995*	0.993*	0.989*	0.998*	0.998*							
18	-0.775*	0.956*	0.991*	0.991*	0.994*	0.994*	0.991*	0.994*						
20	-0.718*	0.924*	0.967*	0.959*	0.956*	0.986*	0.986*	0.982*	0.980*					
22	-0.706*	0.949*	0.980*	0.968*	0.966*	0.985*	0.985*	0.985*	0.986*	0.995*				
24	-0.746*	0.928*	0.958*	0.945*	0.949*	0.959*	0.959*	0.958*	0.970*	0.972*	0.982*			
26	-0.746*	0.928*	0.958*	0.945*	0.949*	0.959*	0.959*	0.958*	0.970*	0.972*	0.982*	1.000*		
28	-0.746*	0.928*	0.958*	0.945*	0.949*	0.959*	0.959*	0.958*	0.970*	0.972*	0.982*	1.000*	1.000*	
30	-0.746*	0.928*	0.958*	0.945*	0.949*	0.959*	0.959*	0.958*	0.970*	0.972*	0.982*	1.000*	1.000*	1.000*

5. Conclusion

This research suggests that a high concentration of nicotine (≥500mg/ml) has inhibitory effects on the corrosion due to the activities of *Desulphovibrio* sp.

ACKNOWLEDGEMENT

The Authors wish to appreciate the financial assistance from STEP-B (IOT), World Bank GRANT from Federal University of Technology, Minna, Nigeria. We wish to also appreciate the Project Manager, Prof K.O. Abubakre, for his support and encouragement and good leadership.

REFERENCES

Akpabio, E.J., Ekott, E.J., Akpan, M.E. (2011). Inhibition of control of microbiologically corrosion in oilfield materials, Environmental Research Journals 5(2): 59-65.

Beech, I.B. and Sunner, J. (2004). Biocorosion: Towards understanding interaction between biofilms and metals. Journal of Current Opinion in Biotechnology, 15:181-186.

Beech, I. B., Gaylarde, C. C. (2008). Recent Advances in the study of biocorrosion an overview. Review of Microbiology 30(3): 1-27.

Cheesbrough, M. (2003). District laboratory practical in tropical countries low priced edition. Cambridge University Press, England.

Cowan, S. T., Steel, K.J. (1993). Manual for the Identification of Medical Bacteria (2nd Edition). Cambridge University Press, London.

Fraunhofer, J.A. (1996). From dentistry to anti-freeze and paints. R&D Innovator 5 (8).

Kakooei, S., Ismail M.C. and Ariwahjoedi, B. (2012). Mechanisms of microbiologically influenced corrosion: A review. World Applied Sciences Journal 17(4): 524-531.

Muyzer, G. and Stams, A. J. (2008). The ecology and biotechnology of sulfate -reducing bacteria. Nature Reviews Microbiology 6: 441–454.

Oyeleke, S.B., Oyewole, O.A., Abioye, O.P. (2005). Microbial Influenced corrosion of metals (a review). Ife Journals of Science 7 (1): 21-24.

Oyewole, O.A. (2011). The Relationship of biofilms and physicochemical properties of soil samples with corrosion of water pipelines in Minna, Niger State, Nigeria. Continental Journal of Microbiology 5(2): 1-10.

Oyewole, O.A., Oyeleke, S.B., Mohammed, S.S.D., Ibrahim, A. (2011). Microorganisms associated with corrosion of water pipeline in Minna, Niger State, Nigerian Journal of Technological Research 6(2):18-24.

Rosa, S.R. (2011). Research trend in innovative anticorrosion additives, APCJ: Asia Pacific Coatings Journal, 24 (2): 20-21.

Sangeetha, M., Rajendran, S., Muthumegala, T.S., and

Krishnagala, A. (2011). Green corrosion inhibitor-an overview Zastitamaterijala 52: 1-17.

Howard, D. (2012). Plant Sources of Nicotine available http://www.ehow.com/list_6898161_plant-sources-nicotine.html

Pottorff, L.P. (2010). Some pesticides permitted in organic gardening, available at http://www.coopext.colostate.edu/4DMG/VegFruit/organic.htm

Rodgman, A., Perfetti, T. A. (2009). The chemical components of tobacco and tobacco smoke. Boca Raton, FL: CRC Press Pp.

Streeter, A.K. (2010). Trillions of killer cigarette butts can be recycled to fight rust available at http://www.treehugger.com/green-food/trillions-of-killer-cigarette-butts-can-be-recycled-to-fight-rust.html.

Schwartz, A. (2010).Toxic cigarette butts could prevent steel from rusting, available at http://www.fastcompany.com/1646593/toxic-cigarette-butts-could-prevent-steel-from-rusting).