



## Degradation of White Water-Based Paints Using Selected Microbial Consortia Isolated from Deteriorated Wall Paints

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### ABSTRACT

This study was carried out to assess the potentials of selected microbial consortia to degrade fresh water-based paints within 35 days. Cost implications, human and environmental resources waste due to paint deteriorations, have been recorded in several references. Thus, this study isolated predominant microbes from scrapes of deterioration wall paints from four different hostels building in Ibrahim Badamasi Babangida University, Lapai, Niger State. Predominant bacterial (*Pseudomonas* + *Bacillus* + *E. coli*) and fungal (*Aspergillus niger* + *Aspergillus fumigates* + *Mucor* sp) consortia were designated as BAC and FUN respectively. A combination of bacterial and fungal consortium designated as [BAC + FUN] and control (without any microorganism) [CTRL] were also assessed. Microbial isolation was done using standard protocol and characterized based on the biochemical properties. Degradation profile of the white water-based paints were assessed with physiochemical parameters (Temperature, Specific gravity, viscosity, Transmittance and absorbance) and sensory properties of the paints. Data obtained were subjected to statistical analysis. Results shows that the prevalence of predominant bacterial (*Pseudomonas*, *Bacillus*, *E. Coli*) and fungal (*Aspergillus fumigates*, *Aspergillus niger*, and *Mucor* sp) isolates accounts for 55.1% and 72.8% respectively. Temperature (28 – 30.2 °C) were not significantly P (<0.05) altered by the microbial induced degradation. However, Specific gravity (0.80 – 1.70), Viscosity (15.1 – 21 x 10<sup>-4</sup> g cm<sup>-2</sup>s<sup>-1</sup>), transmittance (4.0 - 12.5 %T) and sensory evaluation (1.25 – 4.50) were significantly (P<0.05) altered by microbial induced degradation by more than 50%, 28%, 30% and 50% respectively. In conclusion, microbial consortia significantly (P<0.05) degraded white water-based paints within 28 days in a decreasing order of [FUN] > [BAC] > [BAC + FUN] > [CTRL]. Interestingly, control samples were still adjudged to be good by panelists. Considering the cost and waste of material and human resources due to production and distribution chains, it is recommended that manufacturers should incorporate biocides additives as preservative and vendors and end-users should exercise high level of hygiene during handling to limit contaminations.

**Keywords:** Paint, deterioration, biodegradation, microbial consortium

### INTRODUCTION

Paint is a liquid or semi-liquid blend used as a decorative or protective coating on surfaces of wood, metal, walls, stones etc. There are two basic types of paints; oil paint and the water-based. These paints are susceptibility to microbial infections during the production stage and stockpile of packaged paint product. Susceptibility to both physical and chemical prodigy, such as increase in temperature and moisture content, also seems to aid microbial outbreak on paints (La Rosa, 2008).

To have a uniform dispersed mixture, paints are blend into liquid medium of water or oil, the mixture possess viscosity range or form of semi-solid paste to thin liquid. Thin coat of paint is

applied to surfaces including wood, metal, stone and wall with the aid of spray gun, a brush or rollers. Carbon is one of the essential organic constituents of paints which represents a basis for essentially varieties of nutrients that these microbes use to kick-start their growth both in can and on the painted surfaces. This adversely jeopardizes the decorative, adherence and permanence quality of paint. (Da Silva, 2003). Pollution of paints by microbes unfortunately from various points of supply which includes organic constituents for production. Industrial

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plant procedure units and containers for packaging of this paint. (Joutey *et al.*, 2013, Adeleye and Adeleye 1999).

Microorganisms with a unique advance to life; make do with what is accessible as source of nutrition, attach to most surfaces and increase both in number and biomass (Allsopp *et al.*, 2003). Decaying and recycle of materials process by a vast variety of microorganisms can be described as biodegradation which is described to be a valuable process. Bio deterioration is apparently a deleterious process that can be further defined as the deterioration in properties of a material of economic value by microorganisms (Allsopp *et al.*, 2003). The capability of microorganisms to grow in a liquid paint medium before being applied on a dried surface and application on paint film is due to their need for water, hence, bacteria and fungi attack in-can water based coating (EA-UK, 2002). Consequently, neither bacteria nor fungi may grow in solvent-based coatings. However, each class of microorganisms have an effect on the environment. Microorganisms colonize oil and water based film paints both on the inside and outside of the walls of buildings. Bio deterioration characteristics is not only unpleasant but harmful to well-being (Gaylarde and Morton, 2001).

Paint deterioration is one of the problems that paint manufacturers are battling to overcome. Paint industry spends millions on chemicals to preserve paints from microbial attack. Various microbial invasion of paint is cause by bacterial and fungal species. However, anaerobic environment, organic components and microbial efficiency of the packaging components as well as the degree of hygiene of manufacturing plant processing section enhance the deterioration of paints. Microbial build up which causes paint contamination either in wet or dried state confines paint functionality, accompanied by aesthetic and substantial degradation of the painted areas (Okunye *et al.* 2013, Phulpoto *et al.*, 2016). Basic paint preservatives such as microbicides (bactericides, fungicides and algacides) are part of the hurdle technology in paint preservation. Thus, this research aim to assess the white paints degradation potential of selected microbial consortia isolated from deteriorated wall paints.

## METHODOLOGY

### Study Area

This research was carried out on the deteriorated walls of students' hostels of Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria. Lapai town is the headquarters of Lapai Local Government Area adjoining the Federal Capital Territory. It is located on Latitude 9°03'00" N and longitude 6°34'00" E. It has an area of 3051km<sup>2</sup> and a population of 110127 at the 2006 census (Google Map data, 2021).

### Collection of Samples

#### *Paint collection and preparation*

Four different brands of fresh white water-based paints were purchased from paint sellers in Lapai town, Niger State, Nigeria and taken to the microbiology laboratory for analysis. The three brands were bulked together and 3L paint from the bulk were dispensed into four sets of 4L plastic containers marked as A = (Bacterial consortium), B = (Fungal consortium), C = (Bacterial + fungal consortium) and D = (Control). Each set of groups A – D had triplicates.

### Microbial Isolation and Characterizations

The paint scrapes were grounded into powder form using mortal and pistol. One (1g) gram of the grounded scrape was obtained from individual sample and dissolved into 100millilitre sterile distilled water. Tenfold serial dilutions were carried out on each diluent sample by pipetting one (1ml) of diluted sample into a test tube containing 9ml of sterile distilled water. The procedure was repeated until 10<sup>1</sup> to 10<sup>10</sup> was obtained. Individual test-tube was shaken properly to attain a heterogeneous mixture. Cotton wool wrapped with aluminum foil paper was used to cap the individual test tubes.

Using syringe, 1ml aliquots of the dilutions was accurately dispensed into mineral salt medium with this composition: 1.0g di potassium hydrogen phosphate, 0.2g potassium di hydrogen phosphate, 1.0g sodium chloride, 0.005g boric acid, 0.002g calcium chloride, 1.0g ammonium sulphate, 0.5g magnesium sulphate, 0.001g copper sulphate and 20g agar dissolved in 100ml distilled water. The MSM was prepared by dissolving the above composition in 100ml distilled water and sterilized for 20minutes at 121°C. The medium was allowed to cool at room temperature and Ph adjusted to 7.2 using 1M

NaOH. Potato Dextrose Agar (PDA) was used for fungi isolation proportionately (Chikere *et al.*, 2009; Ibiene *et al.*, 2011).

Colonies that appeared on the MSM plates were thus Sub-cultured to acquire pure isolates on nutrient agar (bacteria) and potato dextrose agar (PDA) for fungi. Nutrient agar plates of purified isolates were incubated at 37°C for 24 hours while the PDA plates were incubated at 32°C for 72 hrs. Lacto phenol stain was used to study pure isolates of fungi. On a clean and grease free slide, a wire loop sterilized under flame till red hot, allowed to cool was used to pick a tiny portion of the fungal growth. For identification under the microscope, two drops of lacto phenol was dropped on top the slide containing small portion of fungal growth picked and allowed to stain for five (5) minutes before being rinsed with water on top a rack. When dried, two drops of immersion oil was placed on top the stained slide. The slide was observed under ×10 and ×40 objective lenses (Cheesbrough 2010).

Similar protocol for bacterial and fungal isolates were repeated to assess the microbial profile of the deteriorating paints during the 35 days assessment. Exactly 1 mL of each paint sample were collected after 1 minute agitation of the paint with sterile metal rod and used for microbial examination. Pure isolates of bacteria growth from discrete paint models were determined and characterized using relevant biochemical and morphological procedures for bacterial and fungal isolates (Cheesbrough 2010).

### Microbial Consortium for White Water-Based Paint Degradation

Consortia of bacterial and fungal isolates used for the assessment of microbial induced degradation of fresh white water-based paints were collected from scrapes of deteriorating wall paints of buildings in Ibrahim Badamasi Babangida University, Lapai. These paint scrapes were obtained from four (4) different emulsion surfaces of students' Hostels (A, B, C) and kobo campus. Using sterile scrapping blade, samples were collected into sterile sample bottles and labeled W1, W2, W3 and W4. The bottles were taken immediately to the laboratory in the department of microbiology IBB University, Lapai. Predominant bacterial isolates (*Pseudomonas* + *Bacillus* + *Escherichia sp*) and fungal isolates (*Aspergillus niger* + *Aspergillus fumigates* + *Mucor sp*) are

designated as bacterial and fungal consortium respectively. Each consortium were 5mL standardized (6log10 cfu/mL) peptone broth solution Adopted from Balogu *et al.*, (2017) with slight modifications .

### Physiochemical assessment

#### Temperature

The temperature of the paint sample was determined using a digital thermometer (ST-928). The temperature was dipped into the paint sample after being mixed for two to three minutes. The average reading of the temperature was recorded. The temperature reading was done for 0 to six weeks at three days' interval.

#### Specific gravity

The measurement of the specific gravity of acrylic paint models was done using pycnometer as characterized by Ohwoavworhua and Adalakun (2005). Using a pycnometer of 5ml sterilized. The sterilized pycnometer was weighed with the reading listed as W<sub>1</sub> (g). Reading of the weight of distilled water inside the pycnometry also reported as W<sub>2</sub> (g) after shaking vigorously to expel all bubbles trapped in the pycnometer to avoid false reading. The pycnometer containing the paint weighed and the reading also listed out as W<sub>3</sub> (g). paint sample specific gravity was calculated thus:

$$\text{Specific Gravity (SG)} = \frac{W_3 - W_1}{W_2 - W_1}$$

Where W<sub>1</sub> = the weight of the empty pycnometer  
W<sub>2</sub> = the weight of the pycnometer and distilled water

W<sub>3</sub> = the weight of the pycnometer and paint sample

#### Transmittance and absorbance:

A swift unassuming technique of assessing accumulation of microbes with acceptable spectrophotometer. A digital spectrophotometer (Model:6320D) used in the study of the paint sample was standardized by setting it to read 0.00 for concentration and 100% light transmittance. This procedure was done at one-week interval for six weeks and the result showed was recorded.

#### Viscosity

Measurement of viscosity of the emulsion samples was determined according to the methods of Rammohan and Yassen (2003) of model number (Model: 54200CE) with the aid

of a glass capillary viscometer. A test tube was washed, dried and weighed. 1ml of the paint sample was dispensed into the test tube and weighed. These measurements were recorded in a tabular format. The weight and density was gotten by subtracting weight of the test tube and sample from empty test tube. Time taken for the ball to descend to the bottom reference mark was determined manually using a stop watch (seconds). Viscosity measurements was done at one week intervals for the six weeks' study period.

$$\text{Viscosity} = \frac{2 r^2 g (d_b - d_p)}{9 V}$$

Where; v = velocity (25m/s<sup>2</sup>)

r = radius of ball (0.01m)

g = gravity (10m/sec<sup>2</sup>)

d<sub>b</sub> = density of ball (1.142g/cm<sup>3</sup>)

d<sub>p</sub> = density of paint samples

### **Sensory evaluation**

Sensory properties (colour, smell, texture, solubility) of the plants was evaluated using the ranking method of hedonic 5-point scale (ISO standards, 2021). Twenty panelists (10 trained + 10 untrained) were randomly selected among the university community. Standard guidelines and protocols were observed.

### **Statistical analysis**

Correlation of means accomplished by Chi square and (ANOVA) with the aid of the computer software SPSS version 20 USA

## **RESULTS AND DISCUSSION**

Amongst the predominant bacteria isolated from scrapes of deteriorating wall paints were *Pseudomonas* (21.3%), followed by *Bacillus* (19.1%), *E. Coli* (14.9%), *Staphylococcus* (12.8%) and others (*Proteus*, *Lactobacillus* and *Micrococcus* sp) account for 10.% each (Table 1).

Microorganisms such as *Bacillus*, *Staphylococcus*, *Pseudomonas*, *Proteus*, *Lactobacillus*, *Arthrobacter* and *Micrococcus* are usually present in-can paint which could be as a result of the lack of incorporation of biocides during the production of paints. This is probable because of the presence of few microorganisms such as *Bacillus* and *Pseudomonas* which have been cited to able to degrade as well as utilize hydrocarbon or oil (Okpokwasili and Iteun, 1996). These bacteria isolate also grow well in environments which

contain nutrients that support their metabolic activities. In-can paint degradation is associated with bacteria organisms while fungi isolates are accounted for emulsion paints degradation due to the minimal nutrient requirement for fungi growth, also reported by EA-UK, (2002).

The isolates obtained from degraded paint walls (*Pseudomonas*, *Aspergillus flavus* etc.) shows the pollution of paint preceding their application on surfaces. Raw and packaging materials were observed and these microorganisms were present. A noticed rise in the degree and frequency of deterioration of surfaces painted due to the availability of these isolates also in the containers. Microorganisms isolated from non-deteriorated and deteriorated walls shows differences in the total number. Successive colonization of these painted surfaces by these microorganisms is made not just stress-free but fact also reported by Ogbulie and Obiajuru, (2004).

Predominant fungi isolated from the scrapes of deteriorating wall paint were *Aspergillus fumigates* (36.4%), *Aspergillus niger* (18.2%), *Mucor* (18.2%), and the least group were *Fusarium* (9.1%), *Aspergillus flavus* (9.1%) and *Rhizopus* sp (9.1%) as shown (Table 2). Cappitelli *et al.*, (2004) concur on the ability of fungal agents to degrade paints

The factors enhancing the migration and proliferation of these microorganism on the surfaces applied with paint are related to the severe climatic weather of the tropics leading to the reduction of these constituents of the paint especially the biocides (when added), the location of the structure painted and the nature of the emulsion. Fungi (*Aspergillus niger*) and Bacteria isolates (*Pseudomonas*) present in un-deteriorated painted walls and control in the frequency of occurrence proves that biodegradation is initiated and they are the prime colonizers of these deteriorated surfaces.

A vast range of microorganisms in nature isolated from the degraded painted surfaces include *Bacillus*, *Aspergillus*, *Penicillium* etc. which was also stated by Hurst *et al.*, (2001). There is a huge possibility that the in-flow of

these isolates on the painted surfaces could be linked to dust, dirt, soot, and other contaminants including climatic and environmental conditions. Contamination of paints could also be attributed to make-up, un-processed raw materials, manufacturing plant, the containers for packaging of the paint liquid and wash waters also reported by Gillat (1992).

Some of these isolates (*Lactobacillus* sp) are facultative anaerobes that dwell, thrive and reproduce in anaerobic environment but can still survive in low oxygen environment which is attainable in the packaged paint also reported by Prescott *et al.*, (2002). The fungi isolates was similar to Ishfaq *et al.*, (2015). The steady isolation of these group of isolates could be a pointer that these microorganisms are the actual degraders of paint and painted surfaces with some acting as contaminants.

Temperature of degrading paint was highest (30.1 -30.2 °C) between 14 – 21 days of microbial activities. However, steady steep temperature (27.0 -28.8 °C) increase was recorded between 0 – 7 days and relative stable temperature (28.4 -28.8 °C) between 28 – 35 days. The overall trend showed that microbial consortium had no significant (P<0.05) impact on the temperature of the degrading paints (Fig. 1). Lawrence and Sylvester (2014) observed similar temperature range (28-40°C) as optimum for microbial degradation of paints

Specific gravity as a measure of relative density is an indirect parameter to assess the consistency and quality of paints. Microbial consortia significantly (P<0.05) decreased the specific gravity of the paints by more than 50%, such that FUN (1.65 – 0.8) consortium had the highest impact of 51% reduction, followed by BAC + FUN (1.65 – 1.3) at 21.21%, BAC (1.64 – 1.3) at 20.73% and the least was control (1.7 – 1.65) with less than 3% after 35 days (Fig. 2).

Viscosity as the relative resistance to flow is an indirect parameter to assess the thickness and stickiness of paints, and is considered as one of the most important characteristics to classify paints quality and purpose. Microbial consortia significantly (P<0.05) decreased the viscosity of the paints by more than 28%, such that BAC (21 – 15.1 x 10<sup>-4</sup> g cm<sup>-2</sup>s<sup>-1</sup>) consortium had the highest impact of 28.1% reduction, followed by Bac +Fun (20 – 15.7 x 10<sup>-4</sup> g cm<sup>-2</sup>s<sup>-1</sup>) at 21.21%, Bac (22.5 – 18.1 x 10<sup>-4</sup> g cm<sup>-2</sup>s<sup>-1</sup>) at and the least

was control 22 – 20 x 10<sup>-4</sup> g cm<sup>-2</sup>s<sup>-1</sup>) with 9.1% after 35 days (fig. 3).

Spectrometric transmittance (%T) is the successful light rays that passed through the paint, and is proportional to structural and compositional properties of paints. Thus, it serves as an indirect parameter to assess the degradation rate of paints. Microbial consortia have significant (P<0.05) on the degradation rate (>68%) compared to the control without microbial degraders with less than 35% (fig. 4) measured as 700nm wavelength. Amongst the microbial induced degradation, there was no significant difference (P>0.05) at the degradation of the different consortia. However, BAC had the highest rate of 68% (fig. 4A), followed by BAC + FUN with 67.6% (Fig. 4B) and FUN had the least rate of 67.2% (Fig. 4C). Optimum degradation rates were achieved within 28 days among the microbial induced degradation but it seems that after 35 days assessment, control sample is yet to record optimum degradation rate (Fig. 4D).

All the sensory properties (colour, texture, smell and solubility) of the paints were significantly (P<0.05) altered by the microbial consortia (1.25 – 2.0) compared to the control sample (4.50) using the hedonic scales (Table 2). All the microbial induced degraded paints were rated poorly between strongly disliked to slightly disliked, as FUN scored (1.25) followed by BAC + FUN (1.75) and BAC (2.00). Bacterial consortium induced a greyish-yellow pigment, watery texture, non-agreeable smell and poor solubility of paints. While, fungal consortium induced a greyish-yellow-red pigments, semi-solid precipitate texture, non-agreeable smell and near insoluble of paints (Table 2).

Table 1: Frequency of bacterial isolates associated with deteriorating wall paints

Bacteria Isolates	No of Isolates	Frequency of Distribution (%)
<i>Staphylococcus</i> sp	6	12.8
<i>Pseudomonas</i> sp	10	21.3
<i>Bacillus</i> sp	9	19.1
<i>Proteus</i> sp	5	10.6
<i>Lactobacillus</i> sp	5	10.6
<i>Micrococcus</i> sp	5	10.6
<i>Escherichia coli</i>	7	14.9
Total	47	100

Table 2: Frequency of fungal isolates associated with deteriorating wall paints

Bacteria Isolates	No of Isolates	Frequency of Distribution (%)
<i>Aspergillus niger</i>	2	18.2
<i>Aspergillus flavus</i>	1	9.1
<i>Fusarium</i> sp	1	9.1
<i>Aspergillus fumigatus</i>	4	36.4
<i>Mucor</i> sp	2	18.2
<i>Rhizopus</i> sp	1	9.1
Total	11	100

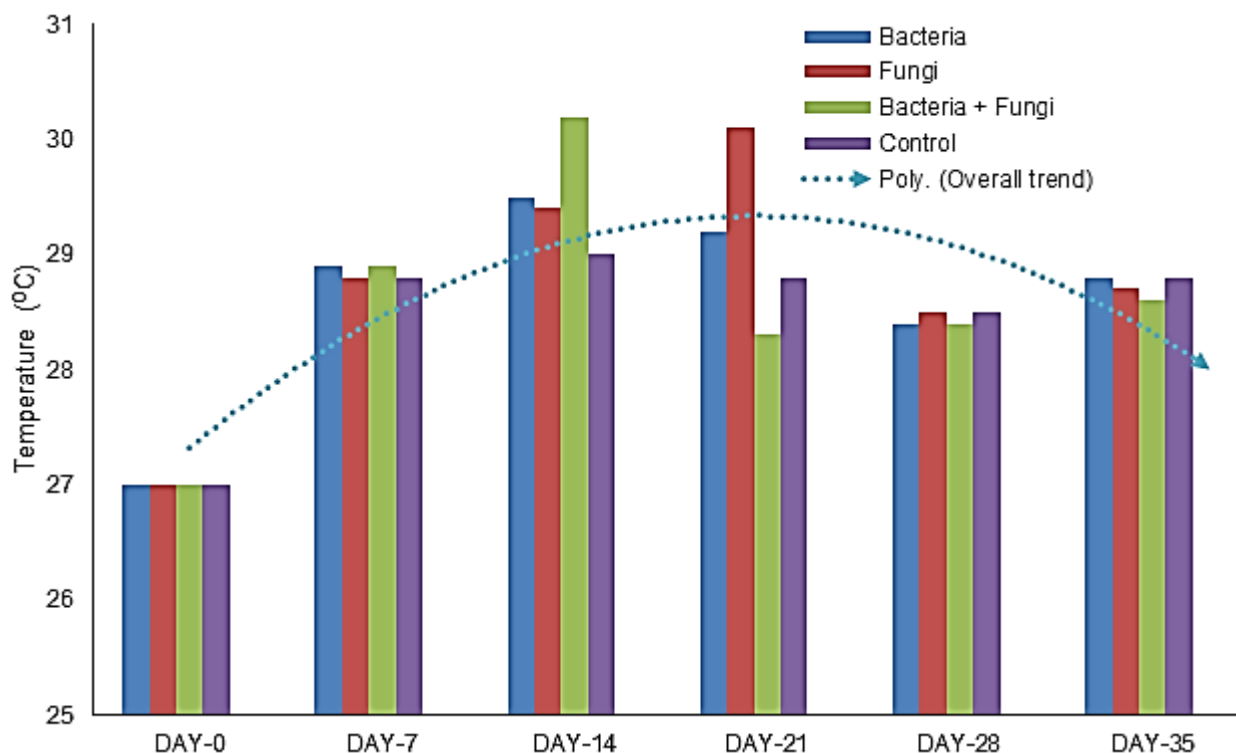


Figure 1: Temperature of white water-based paint Degraded (35days) by microbial agents

Table 3: Sensory properties of white water-based paint Degraded (35days) by microbial agents

Microbial agents	Colour		Texture		Smell		Solubility		5-point Hedonic Overall final score
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	
BAC	White	Greyish	Pastry	Watery	Agreeable	Not agreeable	Soluble	Poor solubility	2.00 <sup>a</sup>
FUN	White	Greyish + spectra of yellow & red	Pastry	Semi- solid (precipitate)	Agreeable	Not agreeable	soluble	Not soluble	1.25 <sup>b</sup>
BAC + FUN	White	Greyish + spectra yellow	Pastry	Watery	Agreeable	Not agreeable	Soluble	Poor solubility	1.75 <sup>a</sup>
CTRL	White	White	Pastry	Pastry	Agreeable	agreeable	soluble	soluble	4.50 <sup>c</sup>

BAC= Bacterial Consortium, FUN = Fungal consortium, BAC+FUN = Bacterial + Fungal consortium, CTRL = Control no microbial consortia

NB: Bar bearing the same alphabets are significantly different (P<0.05)

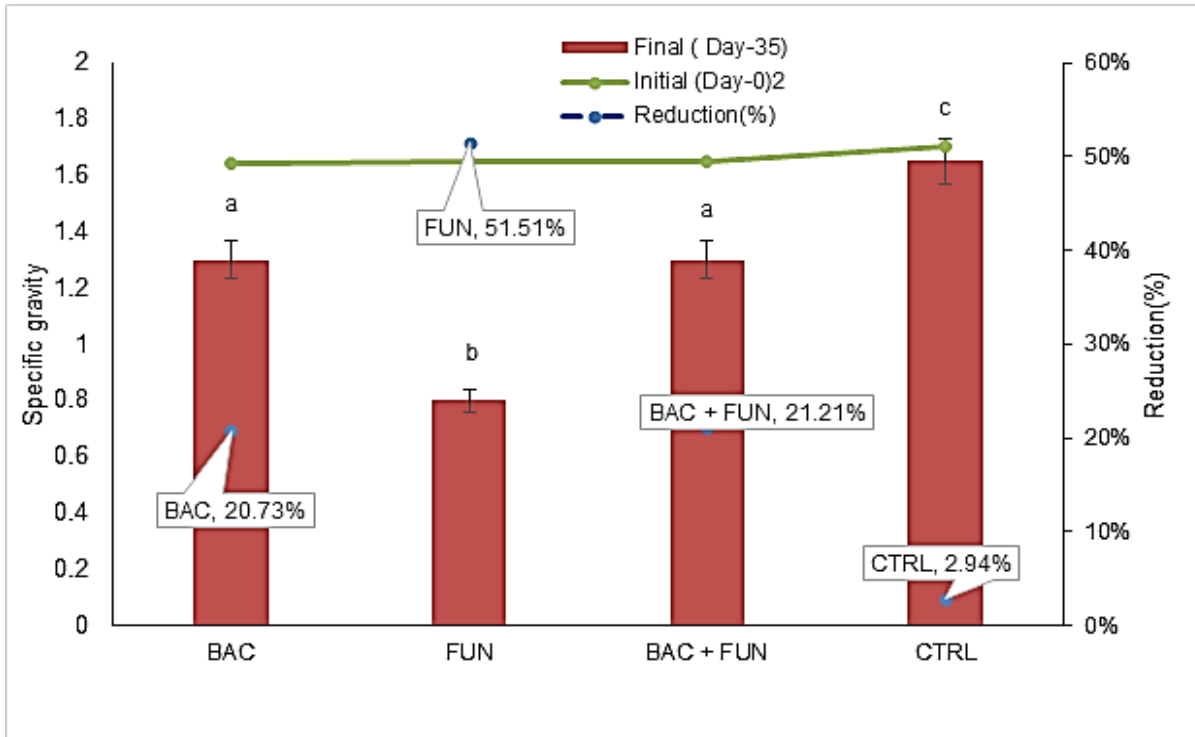


Figure 2: Specific gravity of white water-based paint Degraded (35days) by microbial agents BAC= Bacterial Consortium, FUN = Fungal consortium, BAC+FUN = Bacterial + Fungal consortium, CTRL = Control no microbial consortia

NB: Bar bearing the same alphabets are significantly different (P<0.05)

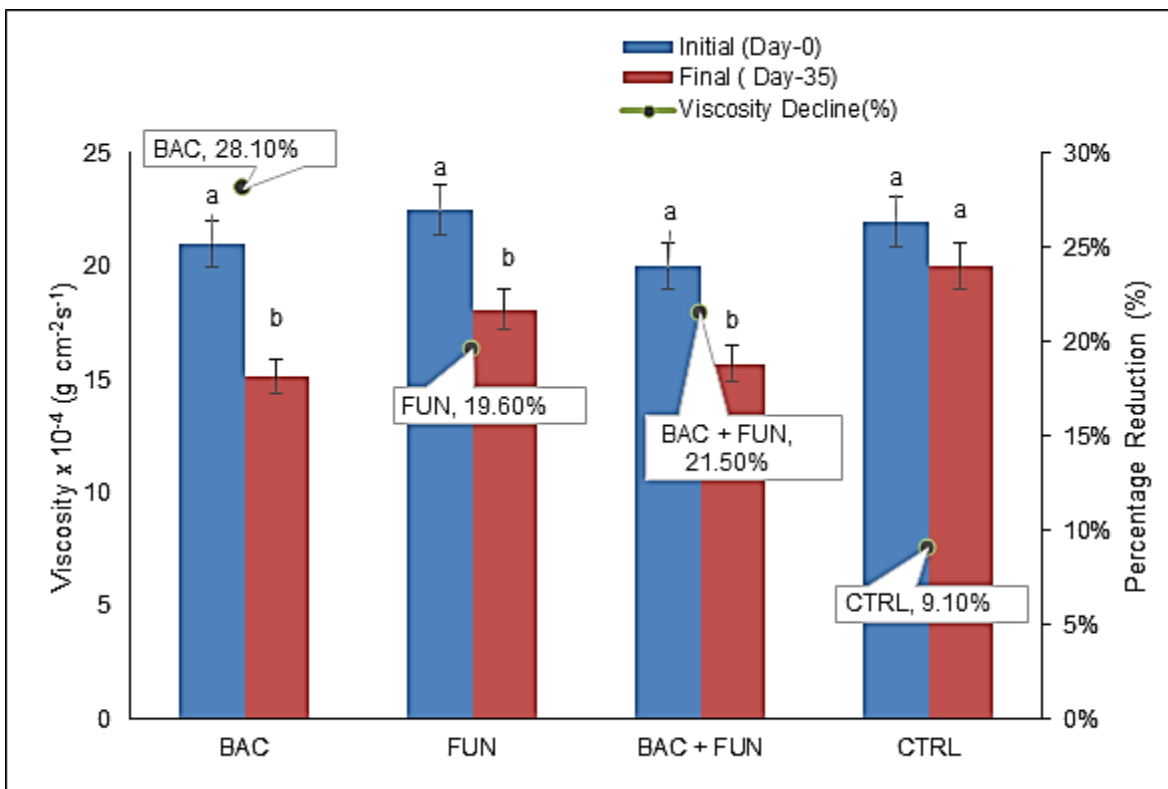


Figure 3: Viscosity of white water-based paint Degraded (35days) by microbial agents BAC= Bacterial Consortium, FUN = Fungal consortium, BAC+FUN = Bacterial + Fungal consortium, CTRL = Control no microbial consortia

NB: Bar bearing the same alphabets are significantly different (P<0.05)

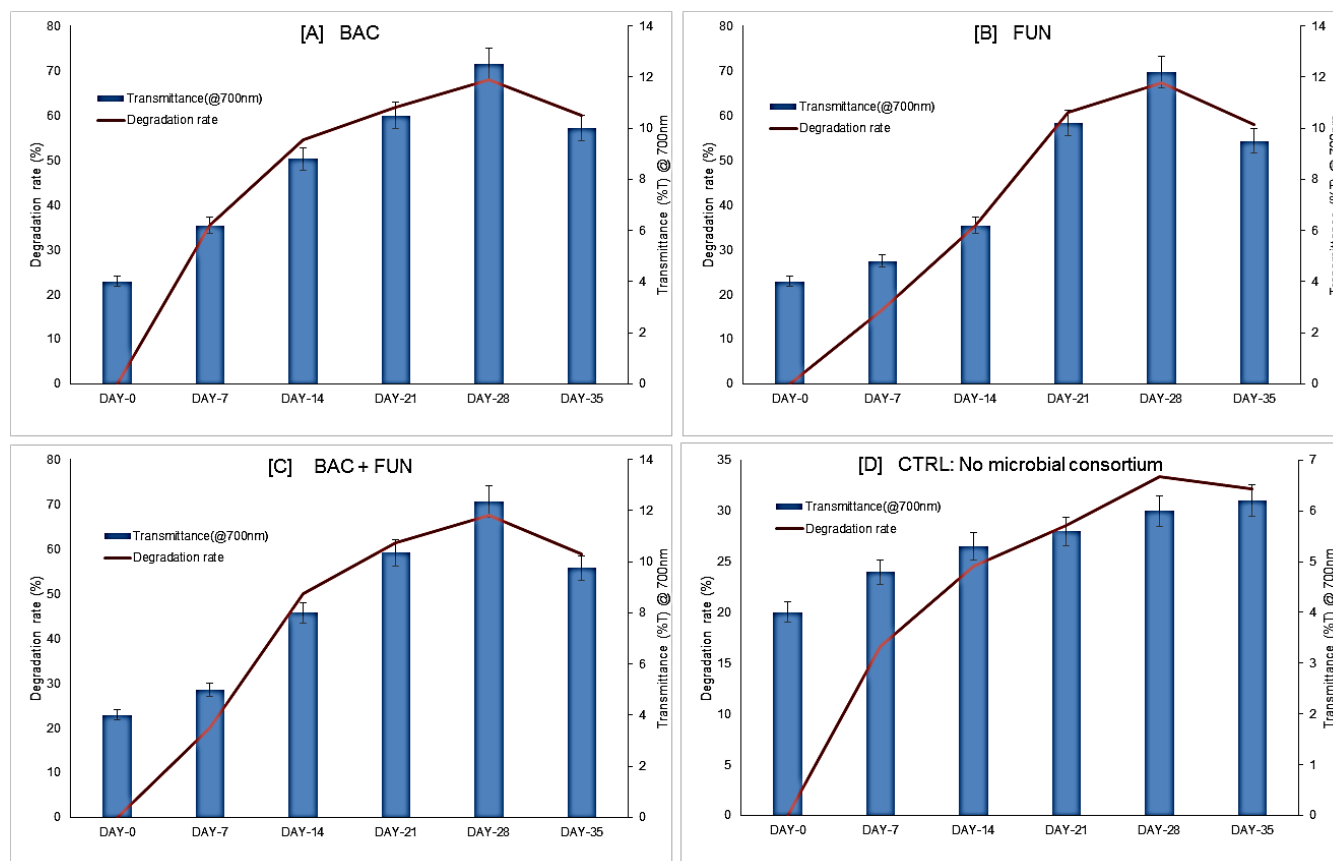


Fig. 4: Degradation rate (%) of white water-based paints by microbial agents using transmittance at 700nm

[A] = BAC: Bacterial Consortium, [A] = FUN: Fungal consortium, [A] = BAC+FUN: Bacterial + Fungal consortium, [A] = CTRL: Control no microbial consortia

**Conclusion**

Microorganisms isolated from this practical can degrade paint within a time frame of five weeks under favourable conditions. These isolates include *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus fumigates*, *Fusarium sp*, *Mucor sp*, *Rhizopus*, *E. coli*, *S. aureus*, *Pseudomonas sp*, *Bacillus sp*, *Lactobacillus sp*, *Micrococcus sp*, *Proteus sp*. This spectrum of bacteria and fungi isolated have the potential to deteriorate water based paints 35 days.

**Recommendation**

Considering the cost and waste of material and human resources due production and distribution chains, it is recommended that should be secured from contamination by the microbes isolated in this study. Also, special biocides that would not have negative impact on the quality of paint should be designed and added into the paint for preservation. Finally, vendor and painters should exercise high level of hygiene to limit contaminations

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