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TEST RESULTS FOR

FUMEKILLER®-BIO & DUSTKILLER®-BIO DEVICES

AIR PURIFICATION PRODUCTS MANUFACTURED BY POWERTECH POLLUTION CONTROLS PRIVATE LIMITED, BENGALURU, INDIA

AIM: TO EVALUATE THE EFFICIENCY OF *FUMEKILLER®- BIO & DUSTKILLER® -BIO* DEVICES (MANUFACTURED BY POWERTECH POLLUTION CONTROLS PRIVATE LIMITED) BY STUDYING THE ANTIMICROBIAL ACTIVITY ON NATURAL AND ARTIFICIALLY INTRODUCED MICROBIAL LOAD IN A CLOSED ROOM

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Introduction

FUMEKILLER®- BIO & DUSTKILLER® -BIO Devices: Powertech Pollution Controls Private Limited, Bengaluru, India has designed and manufactured air purification devices - FUMEKILLER®- BIO & DUSTKILLER® -BIO based on high-efficiency, two-stage electrostatic precipitation technology for trapping particulate matter starting with size as big as 20µm going down to 0.01µm. These particles can be either non-living or living including various bacteria, molds, fungi, SPM etc. The equipment contains a post-filter fitted with reticulated foam media, electrostatic filter modules consisting of a series of positive and negative charged anode wires and aluminium plates (to capture particles) and a set of germicidal UV lamps (254nm wavelength) to neutralise the microbes. Additionally, a post-filter fitted with reticulated foam media impregnated with silver and titanium dioxide nano solution is provided to improve the microbicidal efficiency

Salient features of FUMEKILLER®- BIO & DUSTKILLER® -BIO devices:

- The *FUMEKILLER® - BIO & DUSTKILLER® -BIO devices* are standalone units designed to create a sterile and safe environment and can be used in any closed areas such as laboratories, operation theatres, intensive care units, sick rooms, conference rooms, and in many other applications where control of bio-particles is imperative.
- All filter modules are washable and re-usable over the operational lifetime of the equipment, except for the postfilter which is to be replaced yearly (for normal use). Maintenance and running costs are low as compared to the conventional mechanical filters.
- Contains safety features such as dust-overload and high voltage fault trip circuitry for reliable, safe and efficient functioning.
- These systems contribute to a safer and healthier work environment where toxic airborne pollutants and microbes are removed.
- It can be quickly installed without major changes in the existing area.

Both the devices work by re-circulating the air in the room. However, the FUMEKILLER®- BIO device, has an additional feature of attaching a self-supporting adjustable flexible duct along with a suction hood for dentistry or similar applications where spot specific suction points are required.

Technical Specifications for FUMEKILLER®- BIO Model: FKB500DP for medical applications

Features	FUMEKILLER®- BIO Model: **FKB500DP**
Air flow capacity	500 m^3 per hour (CMH)
Input Voltage	230Volts ±10% @ 50Hz
Power/Current drawn	50watts - power pack
	140watts – suction fan
Filtration method and filter type	Pre-filter: mechanical, MS Frame with reticulated foam (washable)
	Post-filter: mechanical, MS frame with reticulated foam media impregnated with silver (Ag) and titanium dioxide (TiO_2) nano particles (replaceable media). Nano particles activated by UV light 254nm
	Filter modules: 2 nos. electrostatic modules (SS, aluminium, ceramic) Washable.
Filter efficiency	Better than 95% for atmospheric dust and bio particles
Ultraviolet Light	Germicidal, 254nm, 15x2 watts
Suction inlet	Collar with flange diameter 100mm on top of enclosure
Clean air outlet	Grill section towards the lower part of the enclosure and to the rear
Extractor arm	Self-supported, articulated PVC segments and suction hood, 1000mm length
Dimensions(mm) L x W x H	440 x 410 x 1150 (including wheels, excluding extractor arm)
Weight	Approx.70kg

Technical Specifications for DUSTKILLER®- BIO Model: DKB500DP for medical applications

Features	**DUSTKILLER® -BIO Model: DKB500DP**
Air flow capacity	500 m^3 per hour (CMH)
Input Voltage	230Volts ±10% @ 50Hz
Power/Current drawn	50watts - power pack
	140watts – suction fan
Filtration method and filter type	Pre filter: mechanical, MS Frame with reticulated foam (washable)
	Post-filter: mechanical, MS frame with reticulated foam media impregnated with silver (Ag) and titanium dioxide (TiO_2) nano particles (replaceable media). Nano particles activated by UV light 254nm
	Filter modules: 2 nos. electrostatic modules (SS, aluminium, ceramic) Washable.
Filter efficiency	Better than 95% for atmospheric dust and bio particles
Ultraviolet Light	Germicidal, 254nm, 15x2 watts
Suction inlet	3 nos. grill sections at the sides towards the lower part of the enclosure
Clean Air outlet	Grill section at the top of the enclosure towards the front
Dimensions(mm) L x W x H	440 x 410 x 1150 (including wheels)
Weight	Approx.70kg

List of abbreviations:

Abbreviations		Full Name
1. CFU	:	Colony Forming Units
2. LBA	:	Luria Broth Agar
3. PDA	:	Potato Dextrose Agar
4. MRS	:	De Man, Rogosa and Sharpe Agar
5. °C	:	Degree Celsius
6. g	:	gram
7. mL/ml	:	Millilitre
8. UV	:	Ultraviolet
9. Cu. ft.	:	Cubic feet
10. hr	:	Hour

Equipment/ instruments used:

1. Measuring Cylinder
2. Reagent Bottles
3. Petri Plates
4. Micro Pipette- Eppendorf
5. Analytical Balance- Essae
6. Microwave oven-IFB
7. Laminar Air Flow- Nuaire
8. Incubator- New Brunswick Incubator

Reagents and chemicals used:

1. Luria Broth –HiMedia M575-500g
2. Agar powder, Extra pure- HiMedia RM301-500g
3. Potato Dextrose Broth- HiMedia GM403-500g
4. Lactobacillus MRS broth – HiMedia GM369-500g

Preparation of media:

For LBA media: 4 grams of Luria Broth (HiMedia M575) and 3grams of Agar (HiMedia RM301) were suspended in 200 ml Type 1 water and mixed properly.
For PDA media: 4.8 grams of Potato Dextrose Broth (HiMedia GM403) and 3grams of Agar (HiMedia RM301) was suspended in 200 ml Type 1 water and mixed properly.
For MRS media: 11.2 grams of MRS Broth (HiMedia GM369) and 3grams of Agar (HiMedia RM301) was suspended in 200 ml Type 1 water and mixed properly. The prepared media was autoclaved at 15lbs pressure (121°C) for 15 minutes. The media was melted using the microwave oven and approximately 15ml of media was poured onto 90mm sterile petri plates and allowed to solidify.

Experimental design

Experimental Setup:
The experiment was conducted in a closed room (Test room) of approx. 1,080 Cu. ft. volume (9x10x12 feet). All the openings in the room except the door were sealed off. A representative orientation of the room and the air sample collection points have been shown in Fig 1A and 1D. The test device(s) (*FUMEKILLER*® *- BIO* and *DUSTKILLER*® *-BIO*) contained all the components including the pre-filter, electrostatic modules, UV- lamps and the post-filter. To study the baseline microbial load and to maintain the similar air-flow and set up, the control device (without the pre filter, electrostatic module, germicidal UV lamps and the post filter) was used for 1 hour. The representative image of the device(s) used during the study are shown in Fig 1B (without filters) and 1C (With filters and back panel).

Study-1:
The effect of *FUMEKILLER*® *- BIO* ***was studied on the natural microbial load present in a closed room during dry season (March, 2021) with about 16 air changes per hour.***

The control device was set-up at the center of the room and the PDA and LBA plates (to capture the fungal and bacterial load, respectively) were placed at the indicated sampling points as shown in Fig 1A. The plates were removed after each one-hour time-point to collect the passive air sample and to measure the CFU/100mm/hr. The experiment was set-up with test device at the center of the room and the PDA and LBA plates were placed at the indicated sampling points in Fig 1D. The plates were removed at every hour and were replaced with fresh plates for 8 hours to collect the passive air sample and to measure the CFU/100mm/hr. The LBA plates were incubated overnight at 37°C and PDA plates at 30°C for 3 days. The pictures of the plates were taken and the CFU were counted and analysed.

Study-2:
The effect of *FUMEKILLER*® *- BIO* ***was studied on the actively introduced bacterial loading in a closed room with about 16 air changes per hour.***

A human probiotic bacteria Lactobacillus sp. (commercially available as an over-the-counter powder) was used for the study. The number of bacteria in the culture was estimated by serial dilution followed by CFU count as shown in Fig 2. Based on this, the amount of bacteria/ml was calculated to be around 4 million/ml at 0.5 OD. 5ml of *Lactobacillus* sp at OD 1.33 containing approximately 1x107-8CFU were introduced in the test room for 30 minutes. The study protocol was similar to study-1 and the air sample was collected using the MRS plates for 1hour post device application.

Note: In this study, unlike study -1, time-course study could not be performed owing to the fact that the artificially introduced microbes remain suspended (as aerosols) for an hour to the maximum.

Study-3:
The combined effect of *FUMEKILLER*® *- BIO & DUSTKILLER*® *-BIO* ***was studied on the natural microbial load present in a closed room during monsoon season (July and August, 2021) with about 32 air changes exchanges per hour.***

During the rainy season the level of bacterial and fungal spore increased drastically in the environment due to favourable conditions like high moisture. Hence, a study similar to Study – 2 (described earlier) was conducted during the monsoon season in the same test room with damp walls. The control devices were set-up at the center

of the room and the PDA and LBA plates (to capture the fungal and bacterial load respectively) were placed at the indicated sampling points in Fig 1D. The plates were removed after one hour to collect the passive air sample and to measure the CFU/100mm/hr. The experiment was setup with test devices at the center of the room and the PDA and LBA plates were placed at the indicated sampling points in Fig 1D. The plates were removed at every hour and were replaced with fresh plates for 10 hours to collect the passive air sample and to measure the CFU/100mm/hr. The LBA plates were incubated at 37°C and PDA plates at 30°C for 3 days. The pictures of the plates were taken and the CFU were counted and analysed.

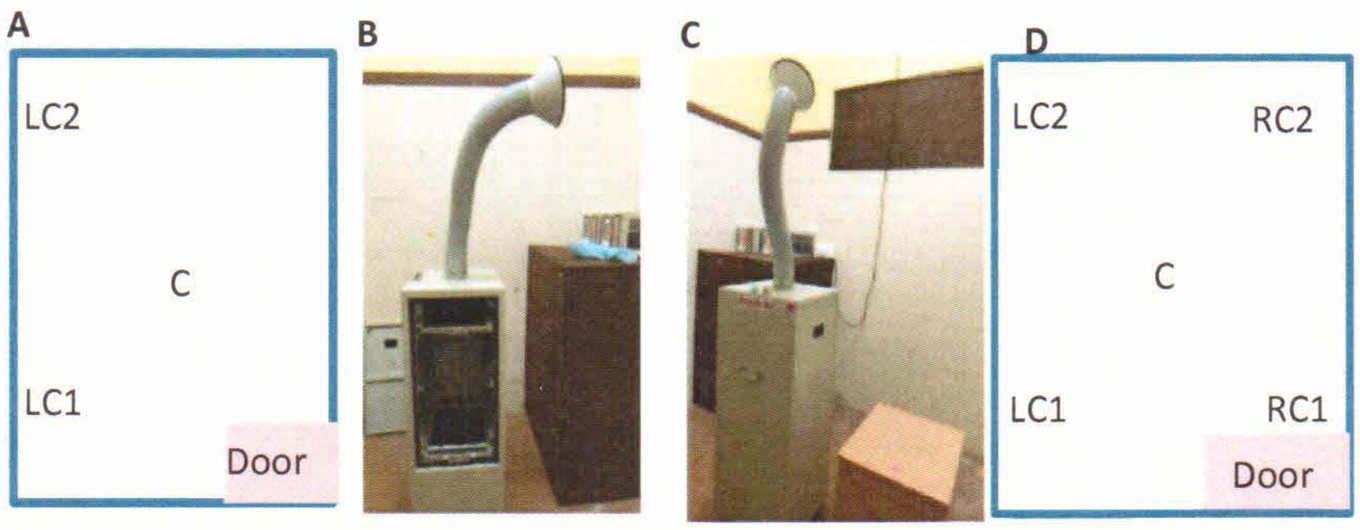


Figure 1: (A) Schematic representation of the air sample collection points with reference to the room entry point (Door). LC1-left corner 1, LC2-left corner 2 and C- Center, (B) The Electrostatic module and UV lamps removed. The basic. Pre and post filters are not altered, (C) The outside panel fixed after removal of electrostatic module and UV before control experiment (D) Schematic representation of the air sample collection points with reference to the room entry point (Door). LC1-left corner 1, LC2-left corner 2, C- Center, RC1-right corner, RC2-right corner

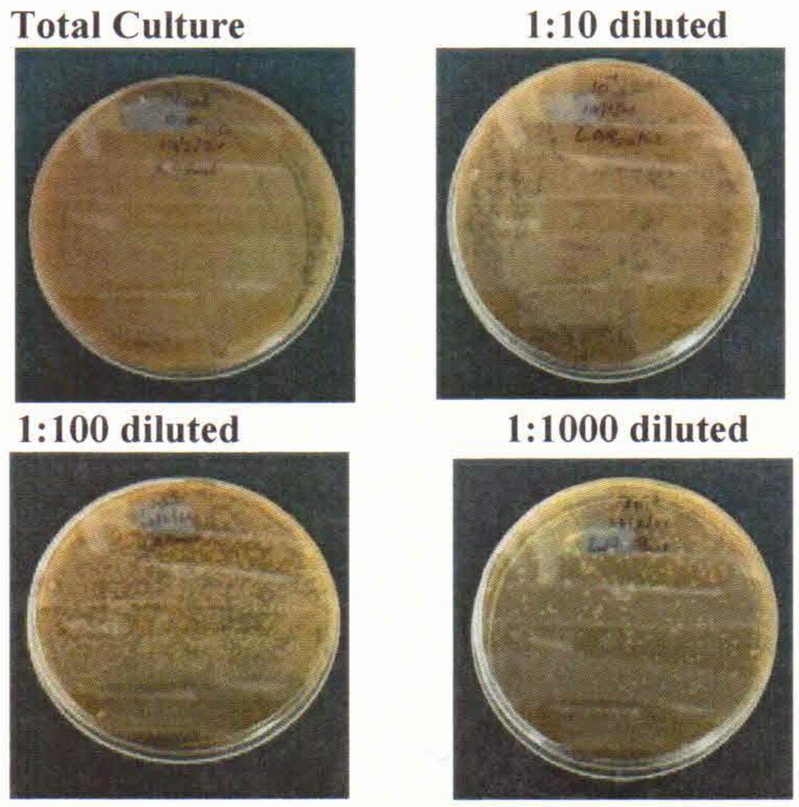


Figure 2: The overnight grown *Lactobacillus* sp grown was plated for MRS agar after indicated dilution. Each dot represents a colony-forming unit (CFU). The plates were incubated at 37°C for 16 hrs.

Observations

Study-1:
In this study, both the fungal (Fig 3A) and Bacterial CFUs (Fig 3B) were measured per 100 mm area (area of the agar plate) per hour of the passive air sampling which was seen to show a decrement within the first hour and the trend was seen to sustain the next 8 hours (Fig 3A).

Study-2:
In this study bacteria (*Lactobacillus* sp.) were actively and artificially introduced in the room to simulate a condition of microbial overload. It was observed that, similar reduction was seen in the levels of *Lactobacillus sp.* within1 hour of the test device application in a closed room (Fig 3C).

Study-3:
In this study, even with high moisture, the fungal (Fig 3D) and bacterial (Fig 3E) CFUs measured per 100 mm area (area of the agar plate) per hour of the passive air sampling showed significant reduction within first few hours and it was sustained over the 10 hours with the test device. The baseline levels were reached at 4-5 hours.

As per the study-1, the percentage reduction over the hours with reference to initial bacterial and fungal CFU load is shown in Table 1 and 2 respectively. The raw values used for making the graphs are given in Appendix -1. The pictures of the PDA, LBA used for this analysis have been provided as supplementary figures in Appendix -2.

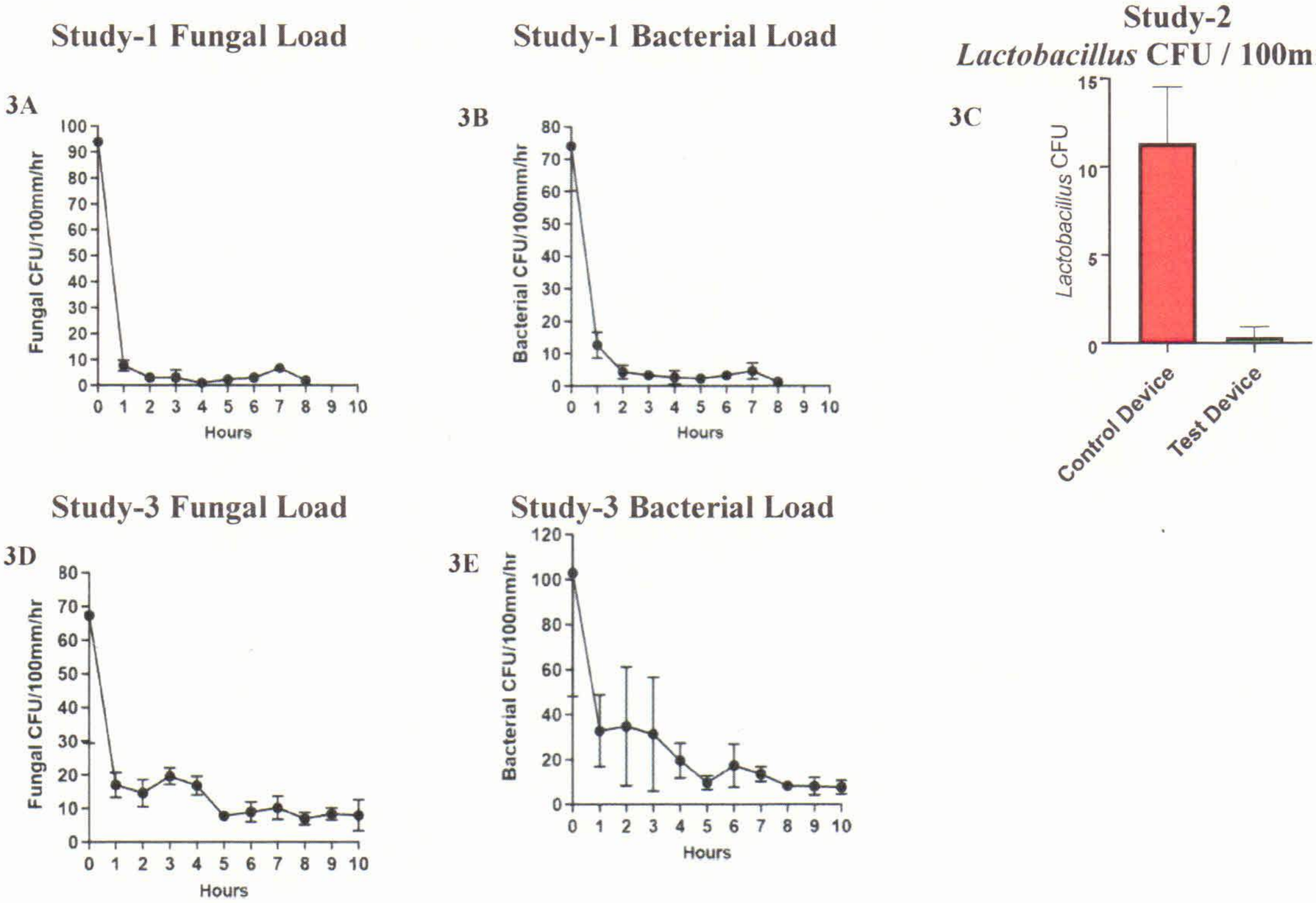


Figure 3: ***Native fungal (A) and bacterial (B) CFU/100mm/hr detected in the test room after application of the test device over the indicated period of time during Study-1. (C) The Lactobacillus CFU/100mm/hr 30 minutes post nebulization and application of the control or test device. D and E) Native fungal (D) and bacterial (E) CFU/100mm/hr detected in the test room after application of the test device over the indicated period of time during Study-3***

Table 1: Percent reduction in Bacterial CFU (cumulative of LC1, LC2 and C air sampling sites)

Hours	CFU/100mm/hr	% Reduction
0	282	0
1	23	91.8
2	9	96.8
3	9	96.8
4	3	98.9
5	7	97.5
6	9	96.8
7	20	92.9
8	6	97.9

Table 2: Percent reduction in fungal CFU (cumulative of LC1, LC2 and C air sampling sites)

Hours	CFU/100mm/hr	% Reduction
0	222	0
1	38	82.9
2	13	94.1
3	10	95.5
4	8	96.4
5	7	96.8
6	10	95.5
7	14	93.7
8	4	98.2

Summary of Observations:

In this study, The FUMEKILLER-BIO® was found to reduce both fungal as well as bacterial load in a 1080 Cu. ft. volume within 1-2 hours of continuous application as compared to the control device.

Appendix-1

Data for Fig 3A:

Hours	Test device (CFU/100mm/hr)		
0	92	94	96
1	10	6	7
2	2	3	4
3	3	6	0
4	1	2	0
5	4	2	1
6	1	5	3
7	6	8	6
8	2	2	2

Data for Fig 3B:

Hours	Test device (CFU/100mm/hr)		
0	89	71	62
1	9	17	12
2	6	5	2
3	4	3	3
4	5	2	1
5	1	3	3
6	3	3	4
7	2	7	5
8	0	1	3

Data For Fig 3C:

Plate Location	Control Device (CFU/100mm/hr)	Test Device (CFU/100mm/hr)
LC1	10	0
LC2	9	0
C	15	1

Data For Fig 3D:

Hours	Test Device (CFU/100mm/hr)				
0	52	193	67	97	106
1	7	38	38	31	50
2	14	30	32	80	18
3	22	15	27	17	76
4	15	33	20	15	15
5	9	5	13	10	12
6	11	11	34	16	15
7	13	9	15	18	13
8	7	9	8	12	6
9	7	15	8	6	5
10	7	13	6	8	5

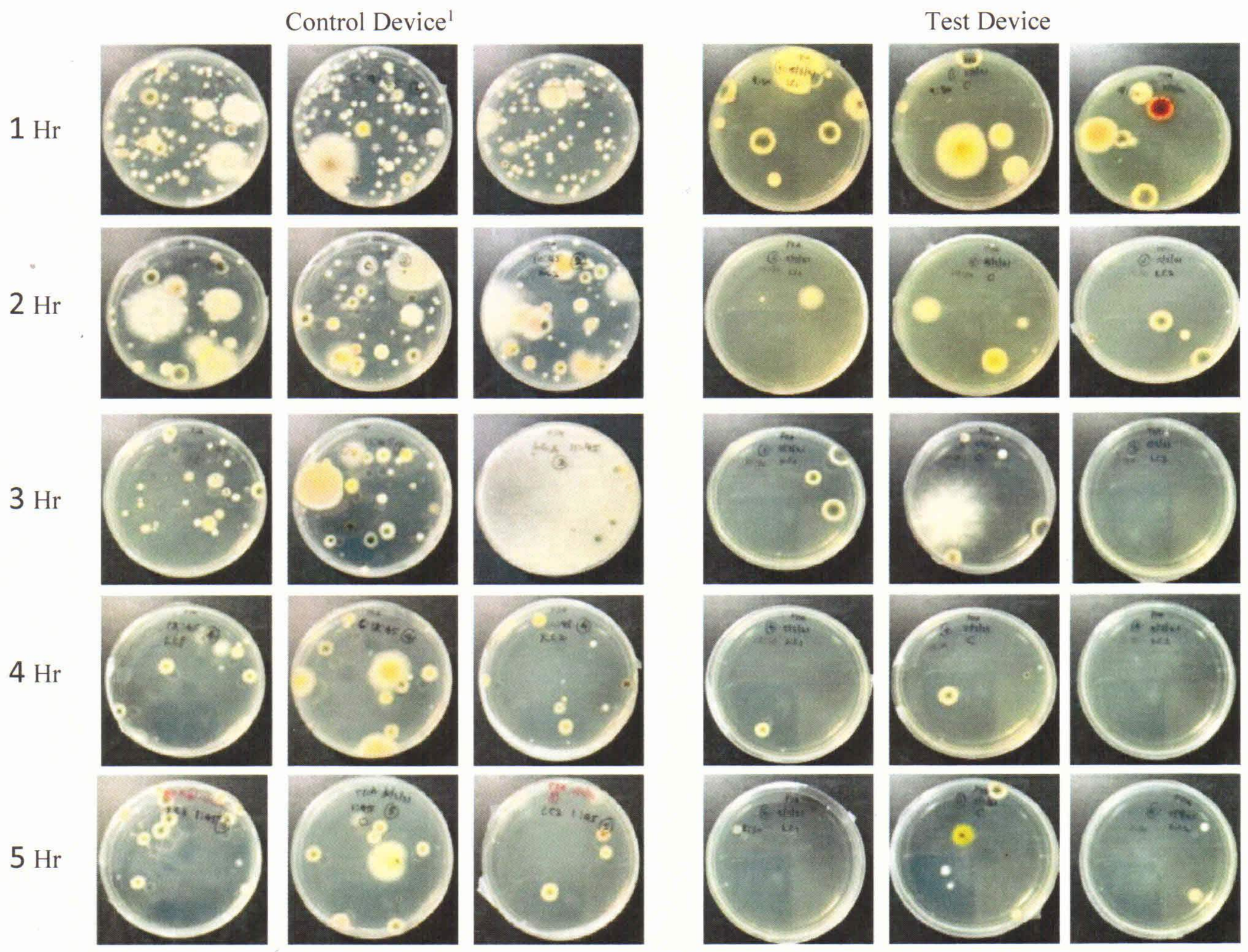
Data For Fig 3E:

Hours	Test Device (CFU/100mm/hr)				
0	77	124	47	22	67
1	14	19	20	12	20
2	12	17	19	9	16
3	17	22	22	20	17
4	16	16	20	13	19
5	8	10	7	7	7
6	7	8	14	7	9
7	10	16	9	9	7
8	5	9	8	5	8
9	7	9	10	6	10
10	4	16	6	7	7

Appendix-2

Supplementary figure 1:

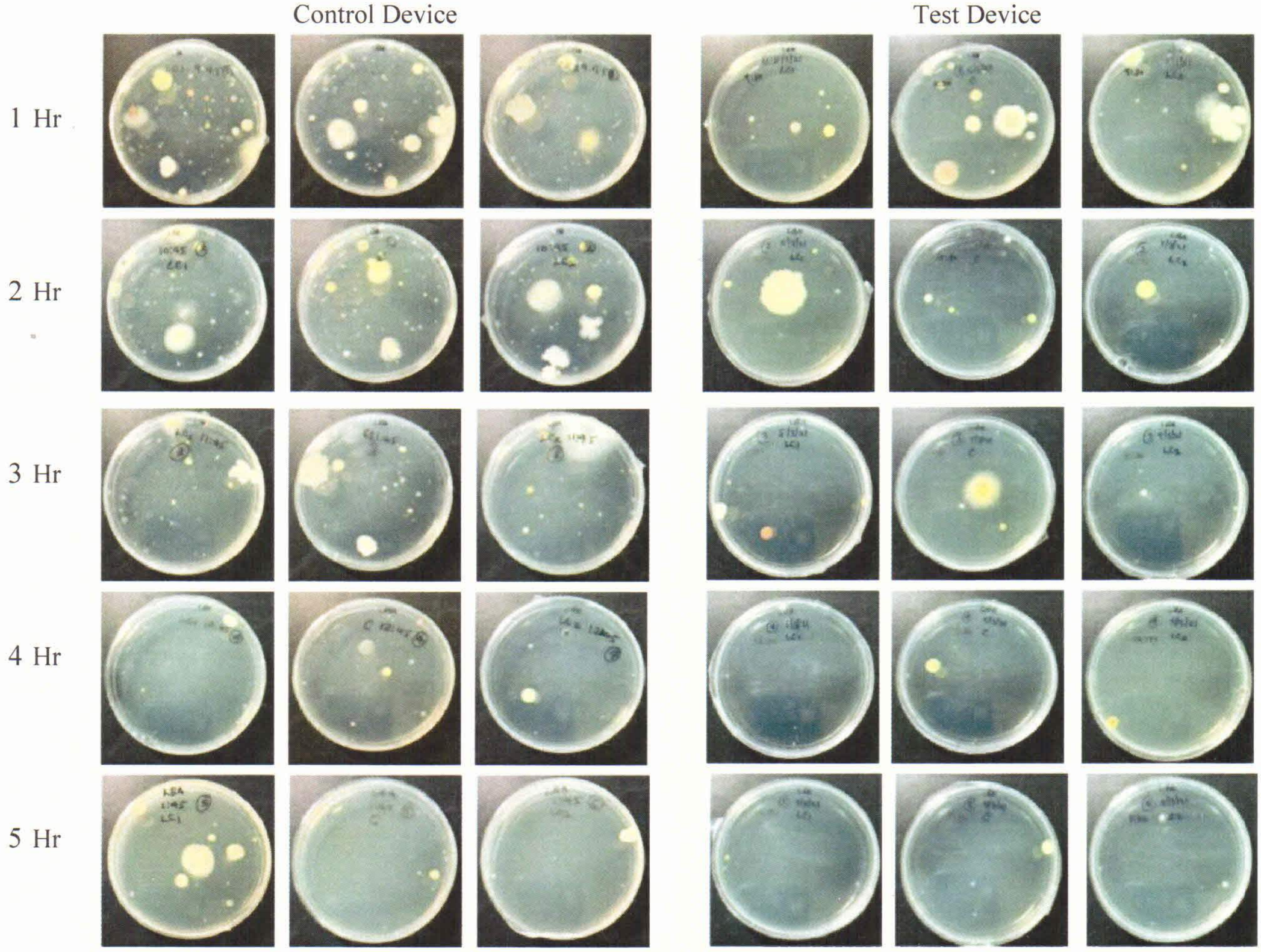
Images of PDA pates from study-1 showing native fungal growth.



[1] Control device is the air purifier unit without the ESPs.

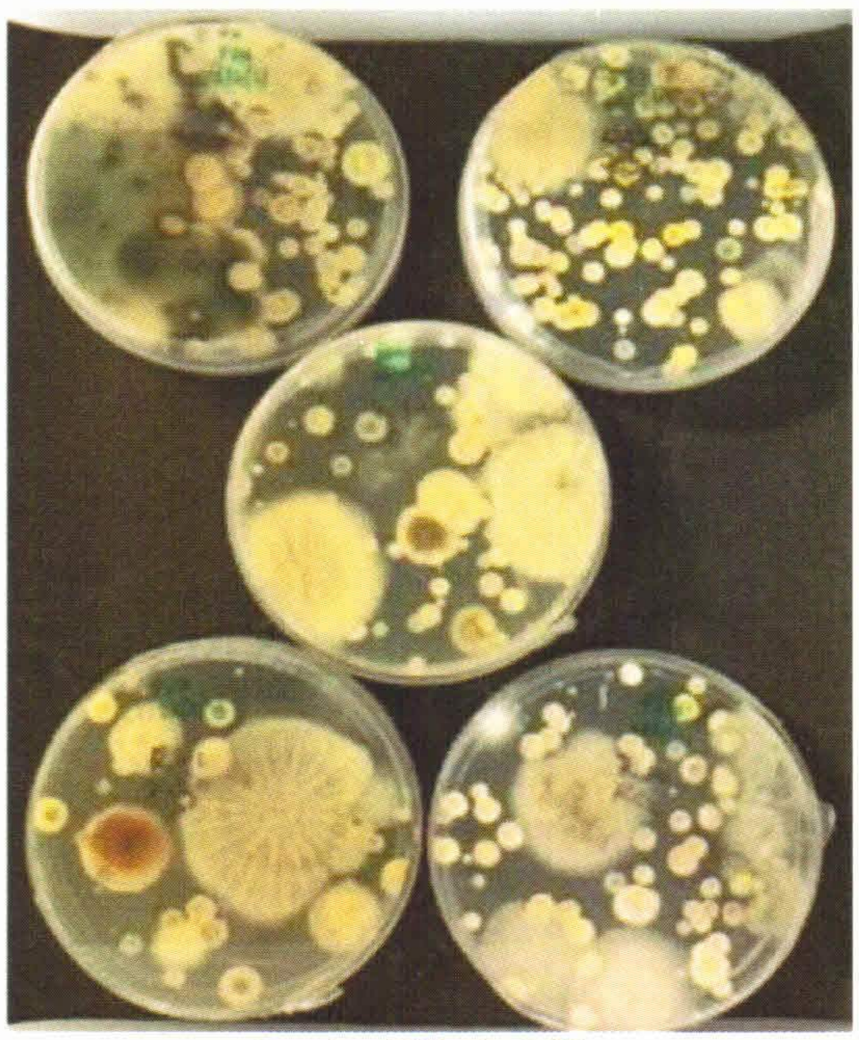
Supplementary Figure 2:

Images of LBA pates from study-1 showing native bacterial growth.

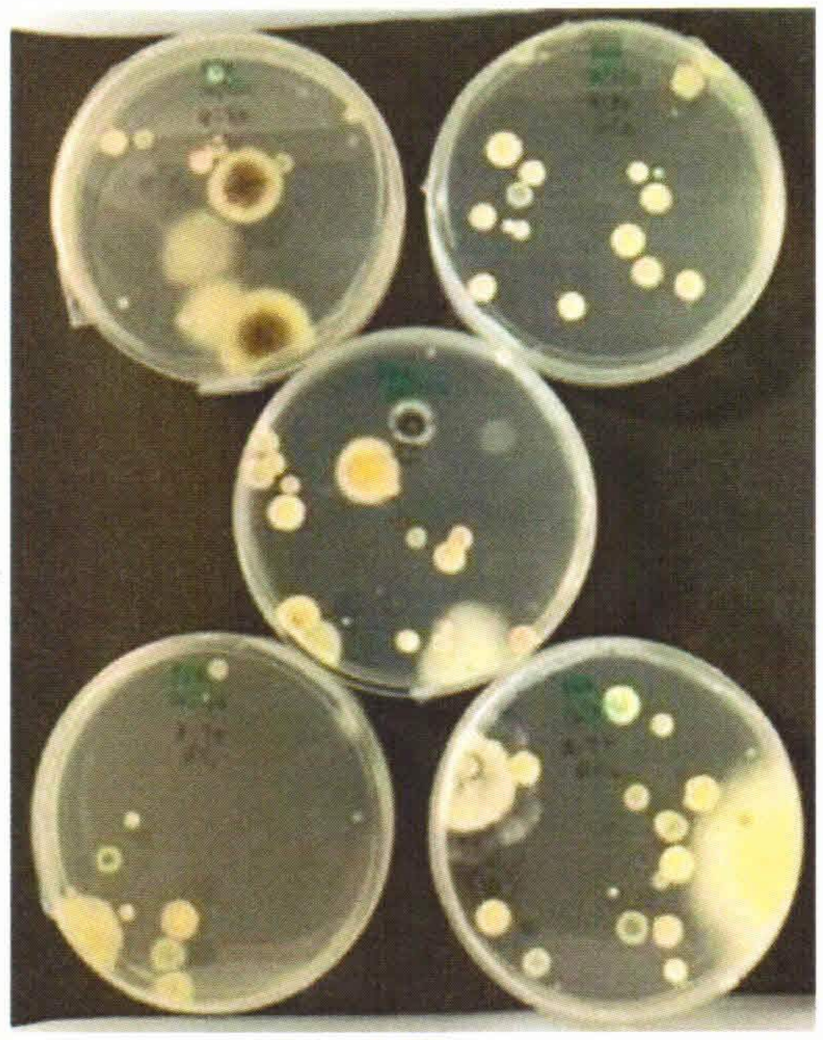


Supplementary figure 3:

Images of PDA pates from study-3 showing fungal growth.



Control Plate 0 Hr



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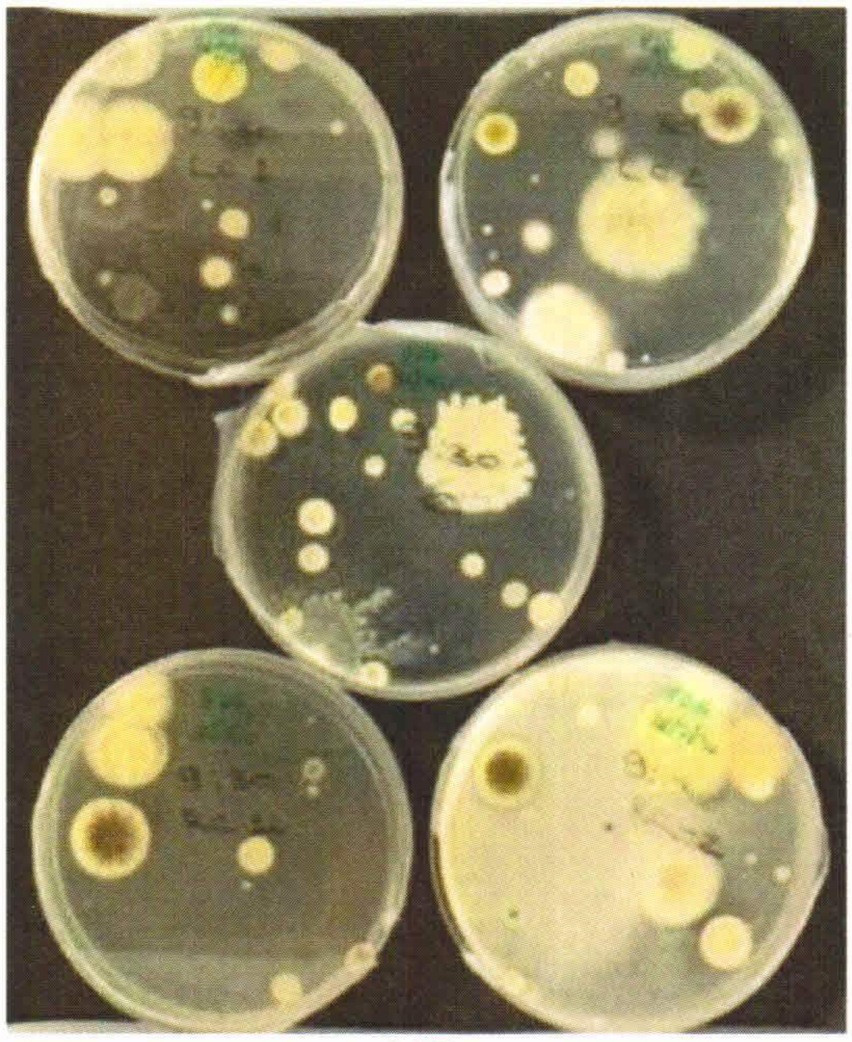

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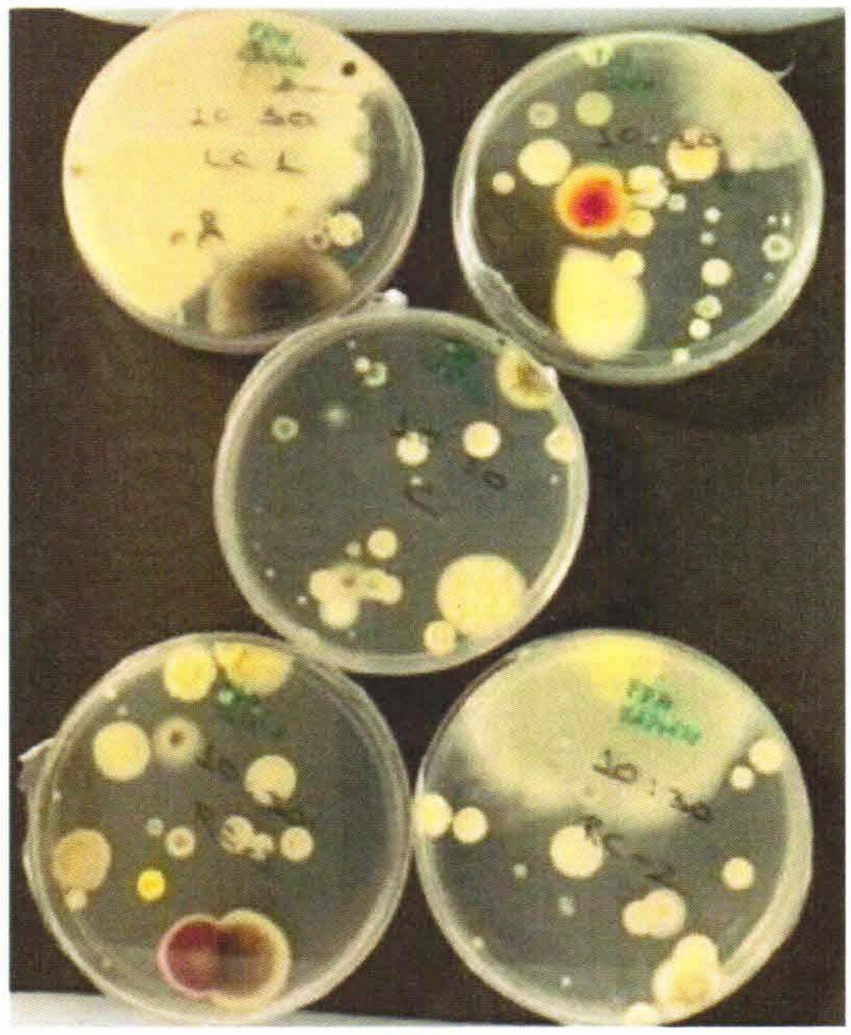

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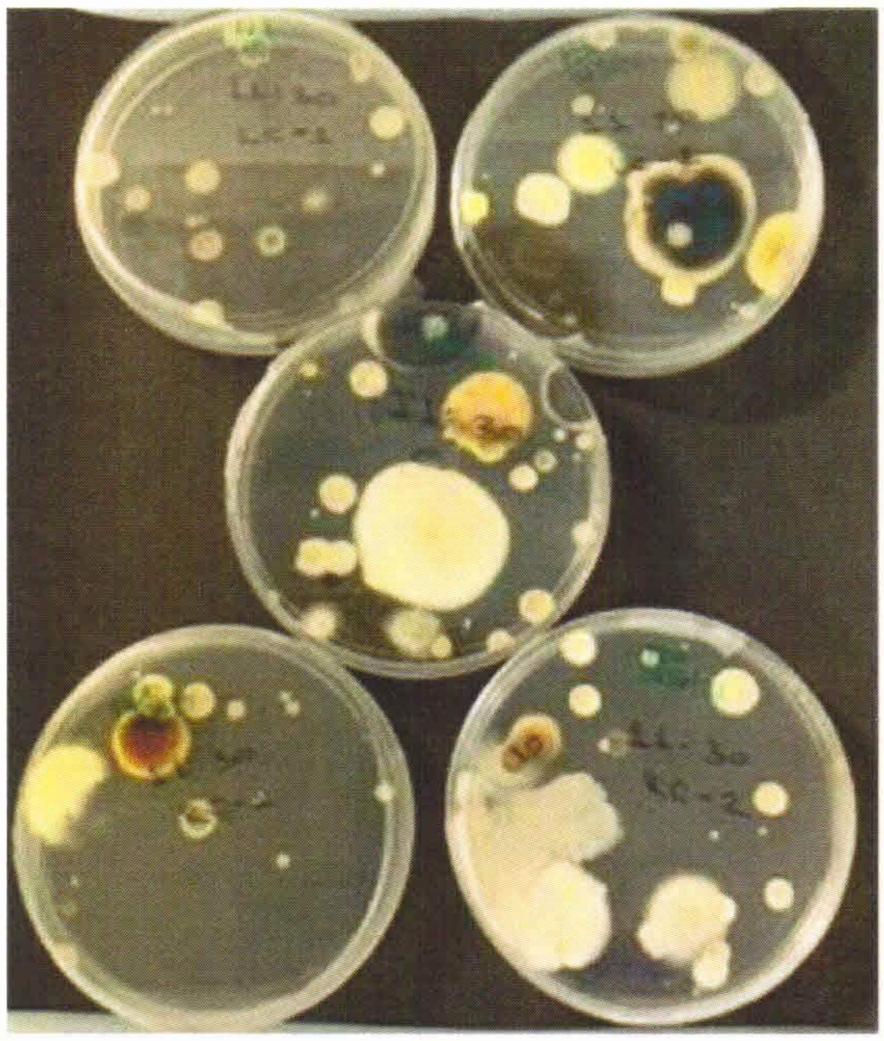

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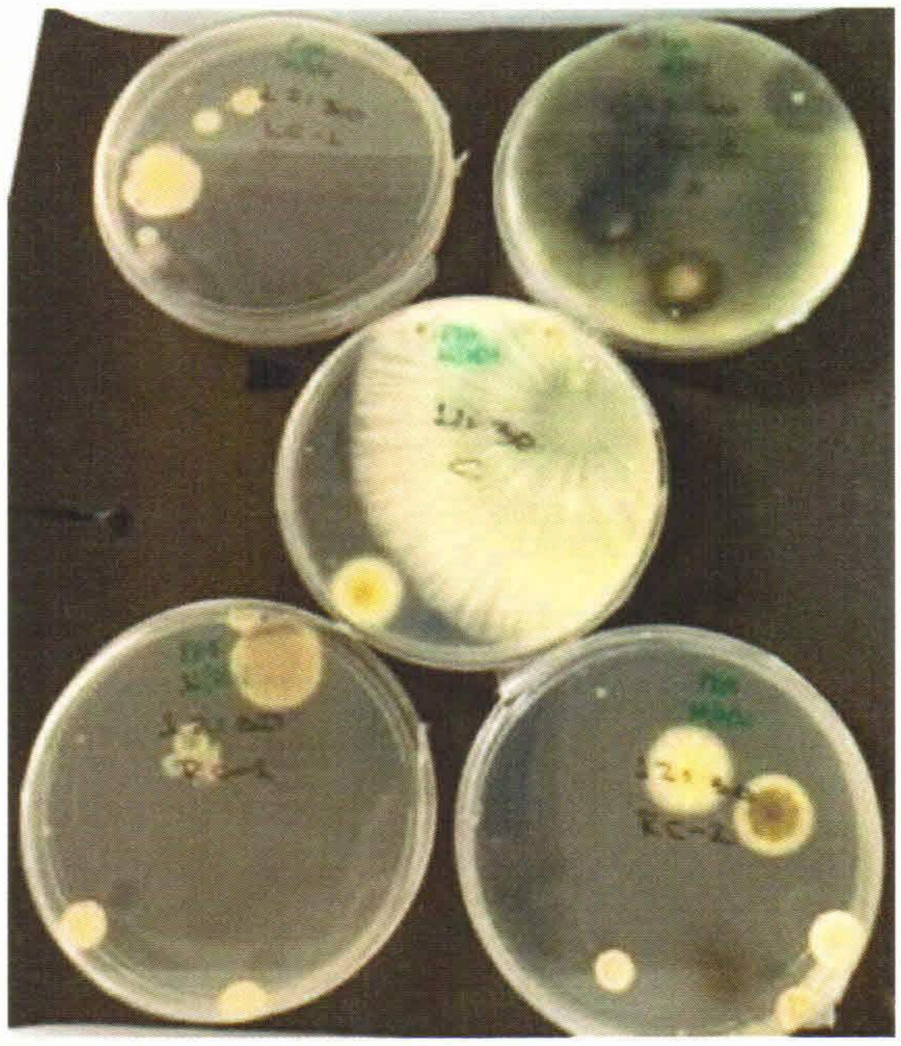

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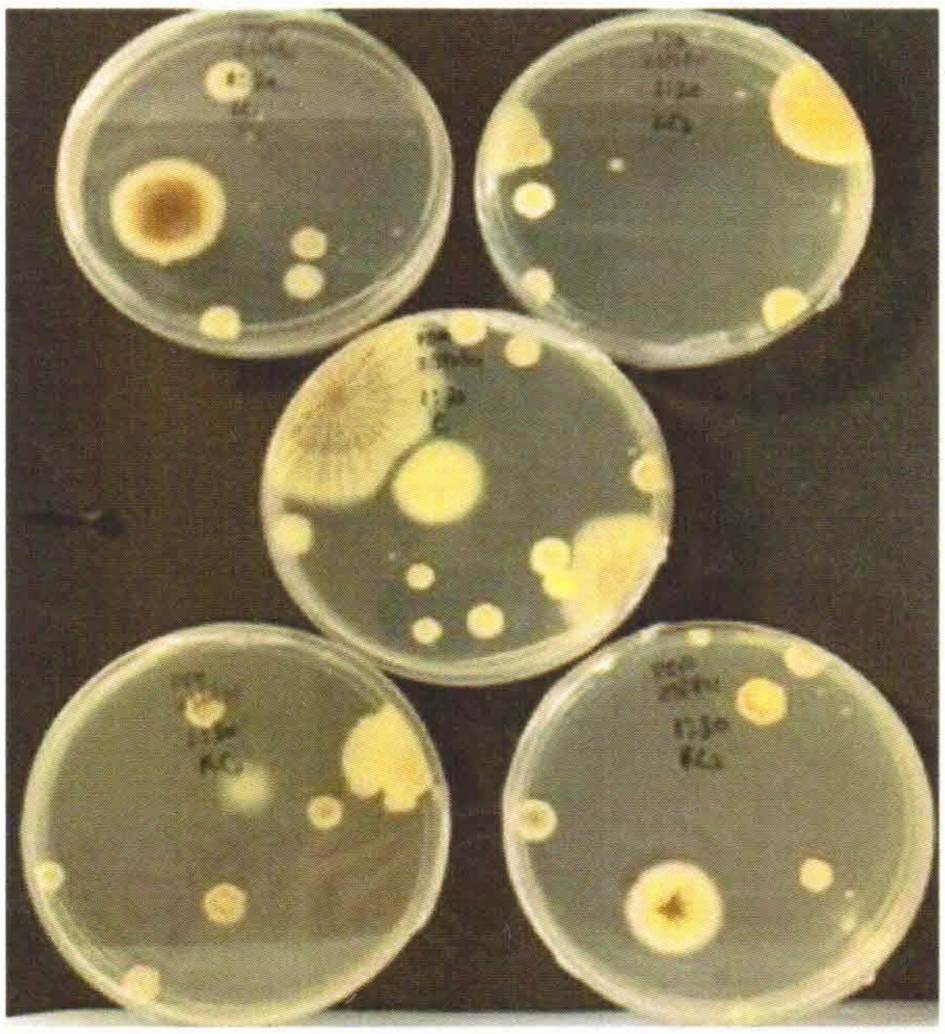

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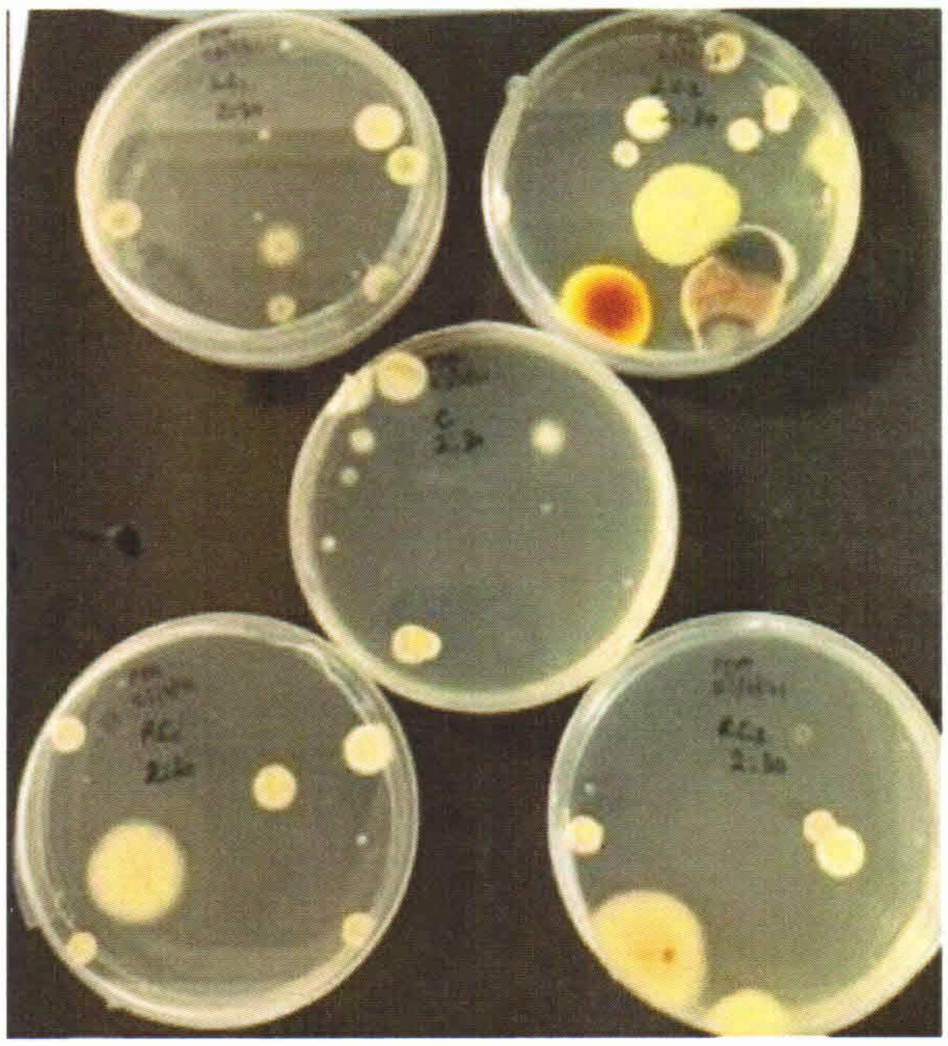

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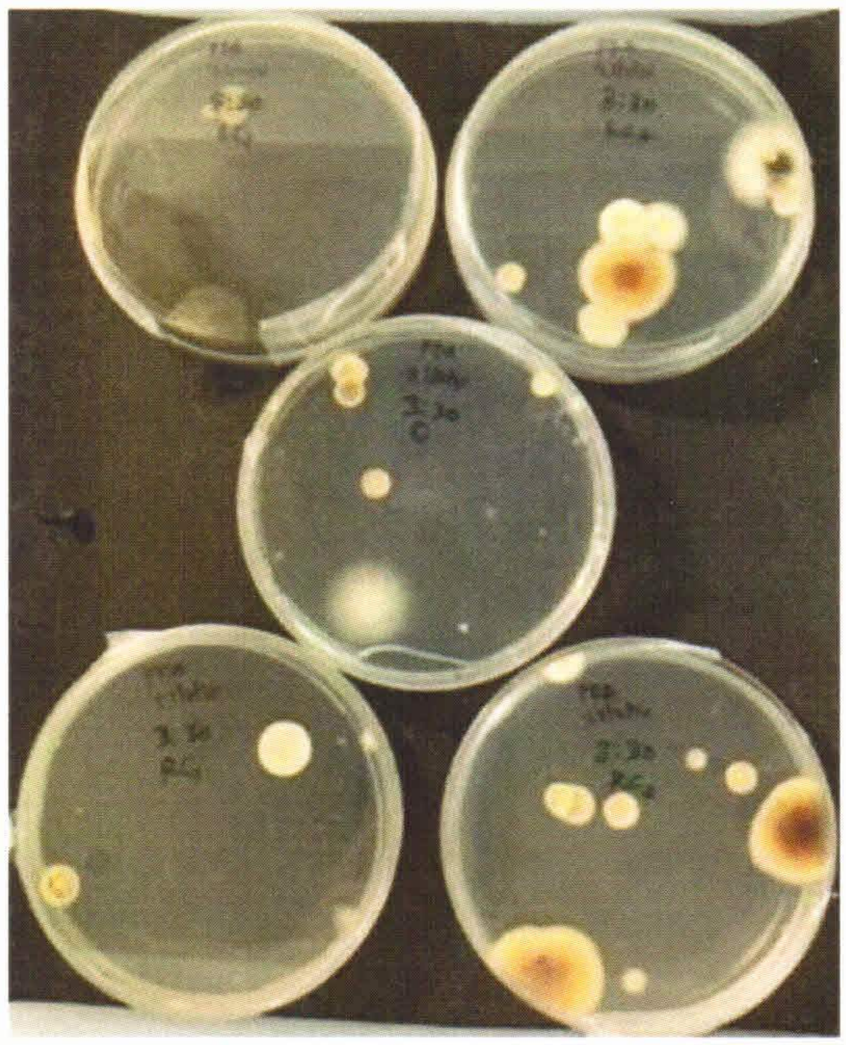

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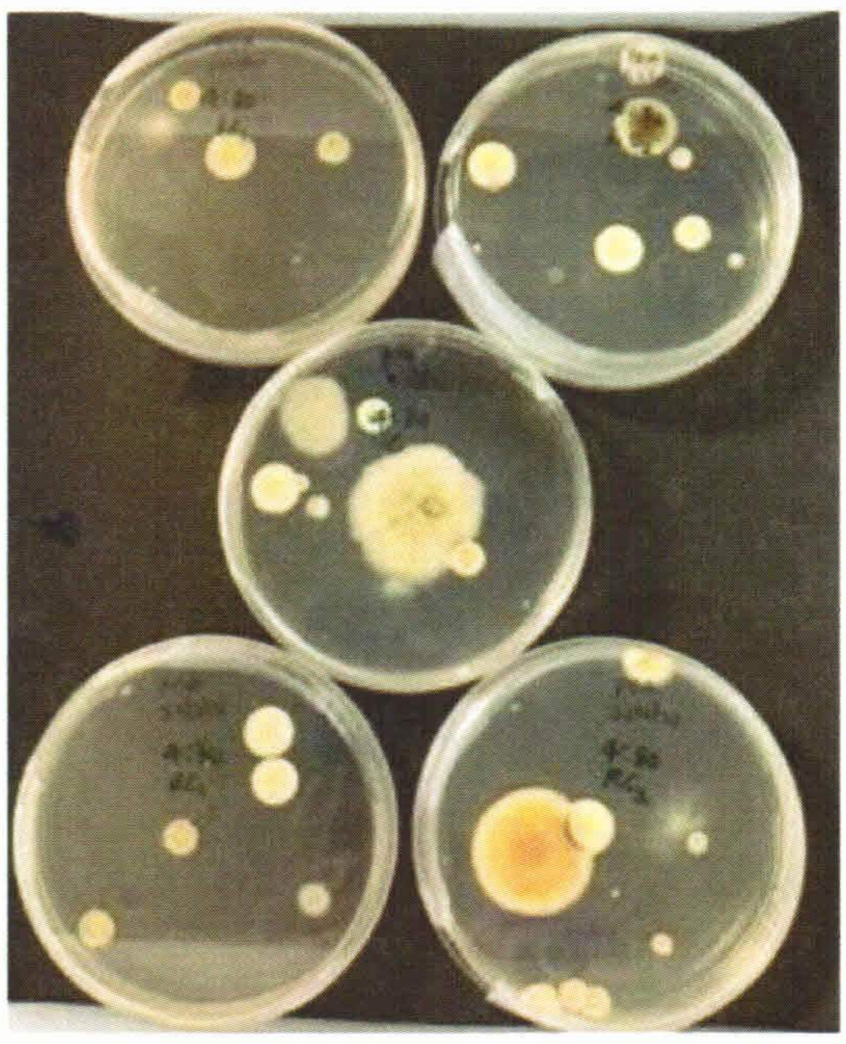

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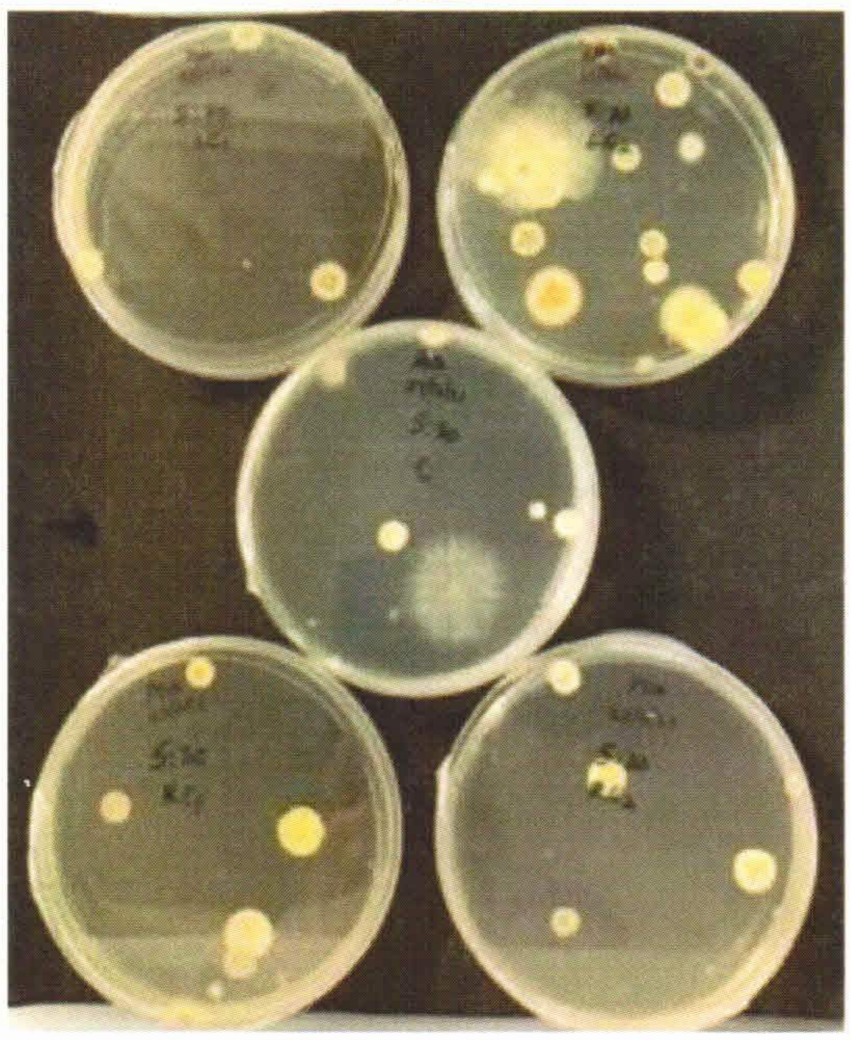

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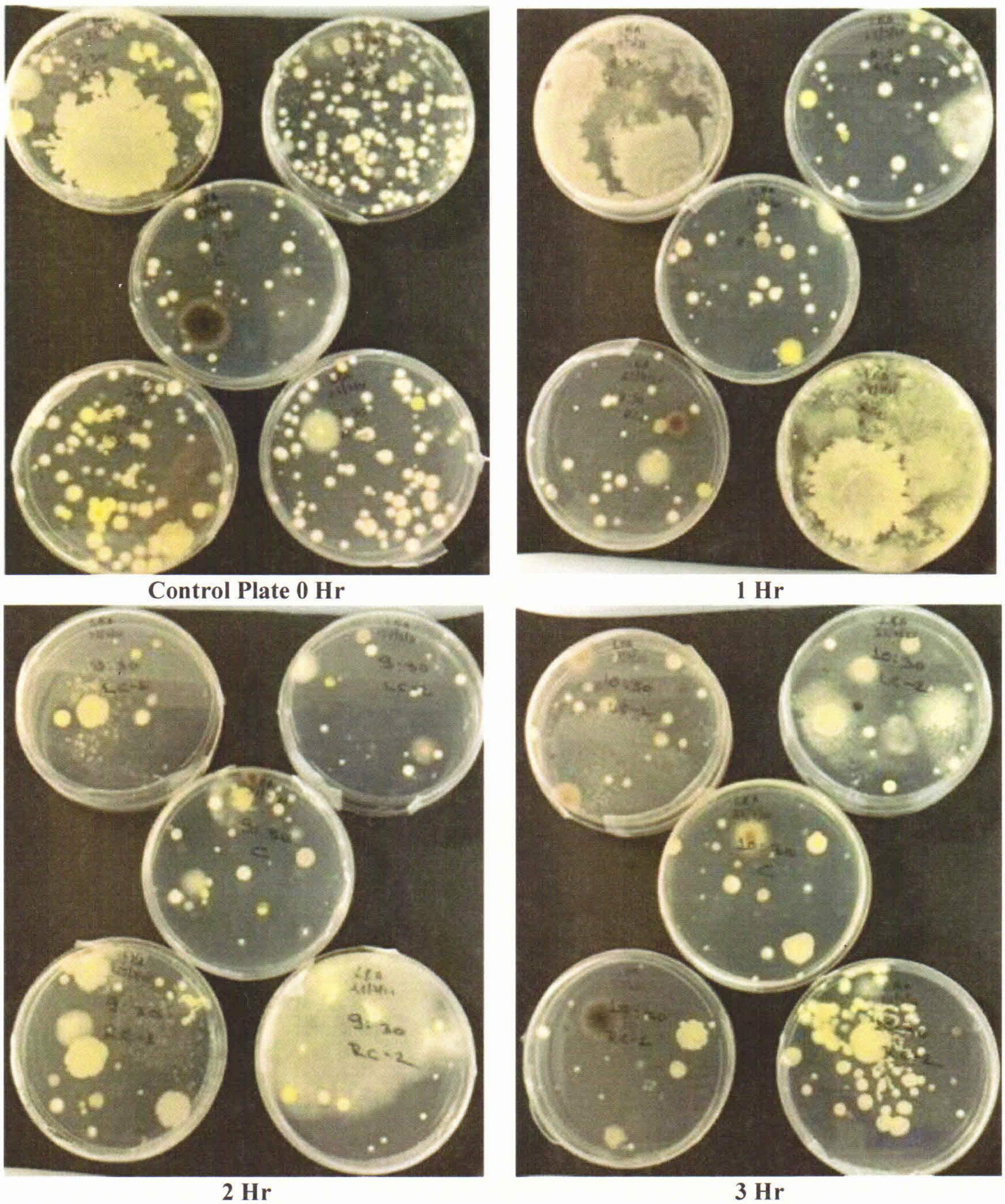
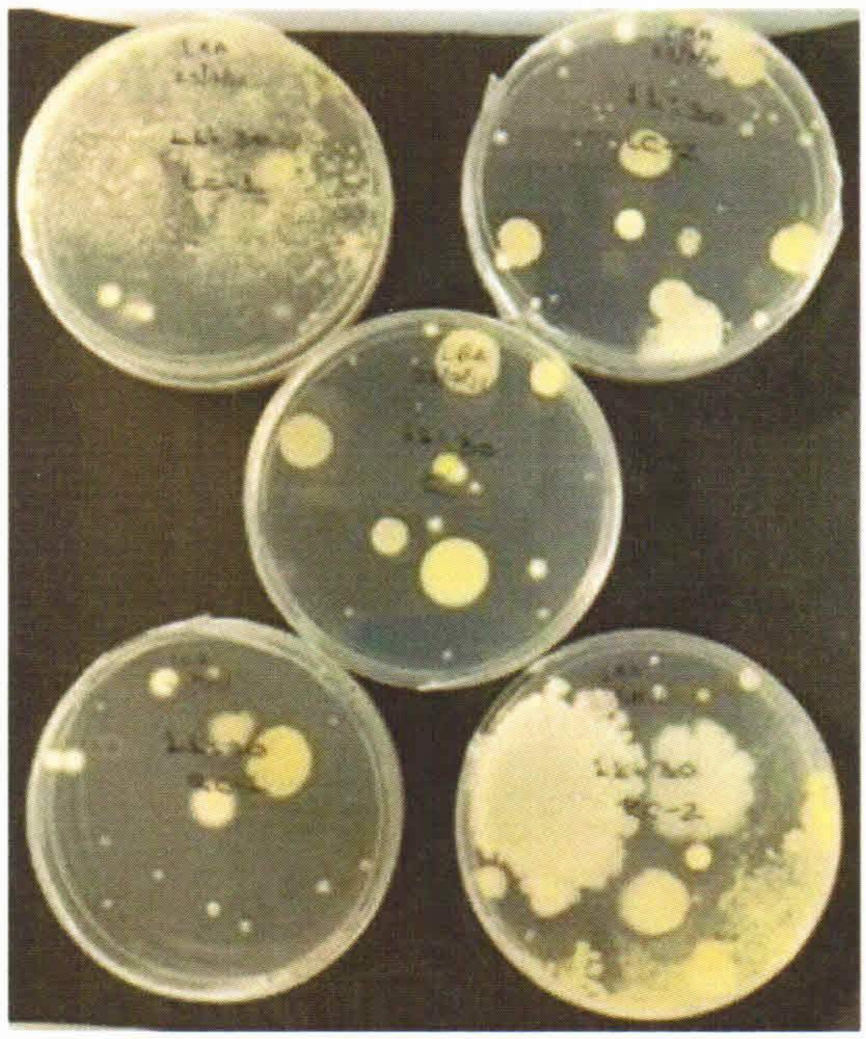
Supplementary figure 4:

Images of LBA pates from study-3 showing bacterial growth.



Control Plate 0 Hr **1 Hr**

2 Hr **3 Hr**



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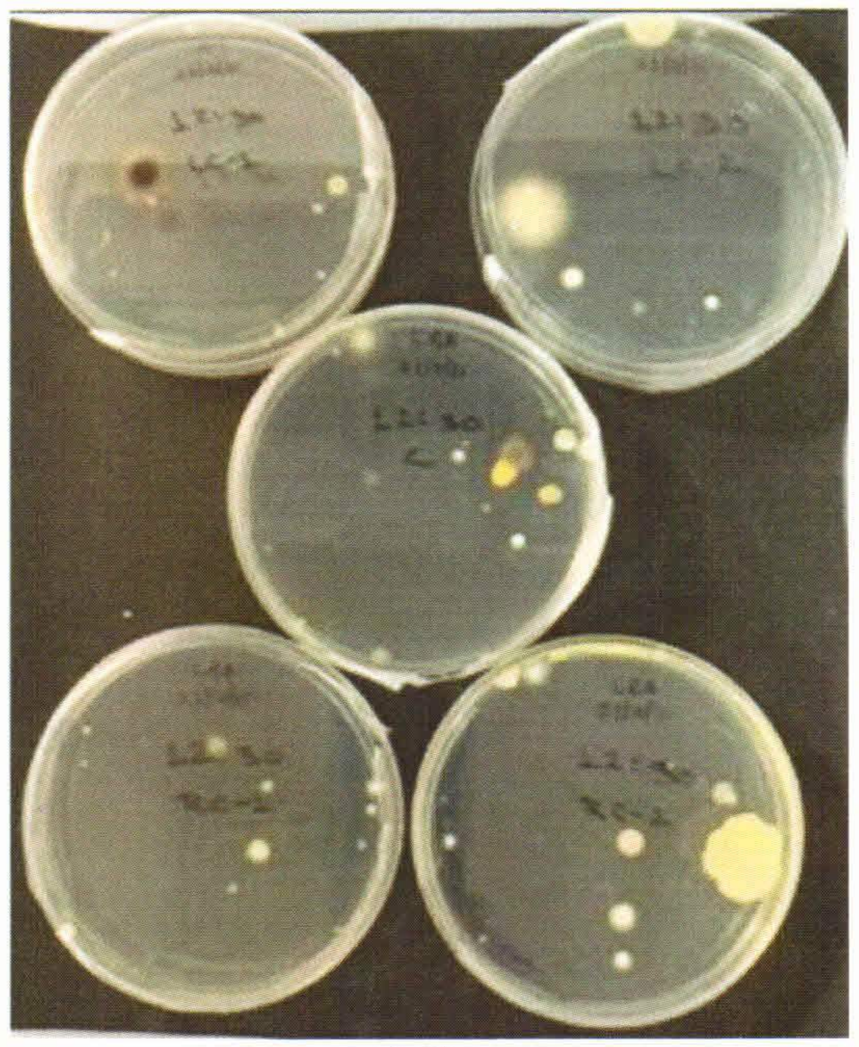

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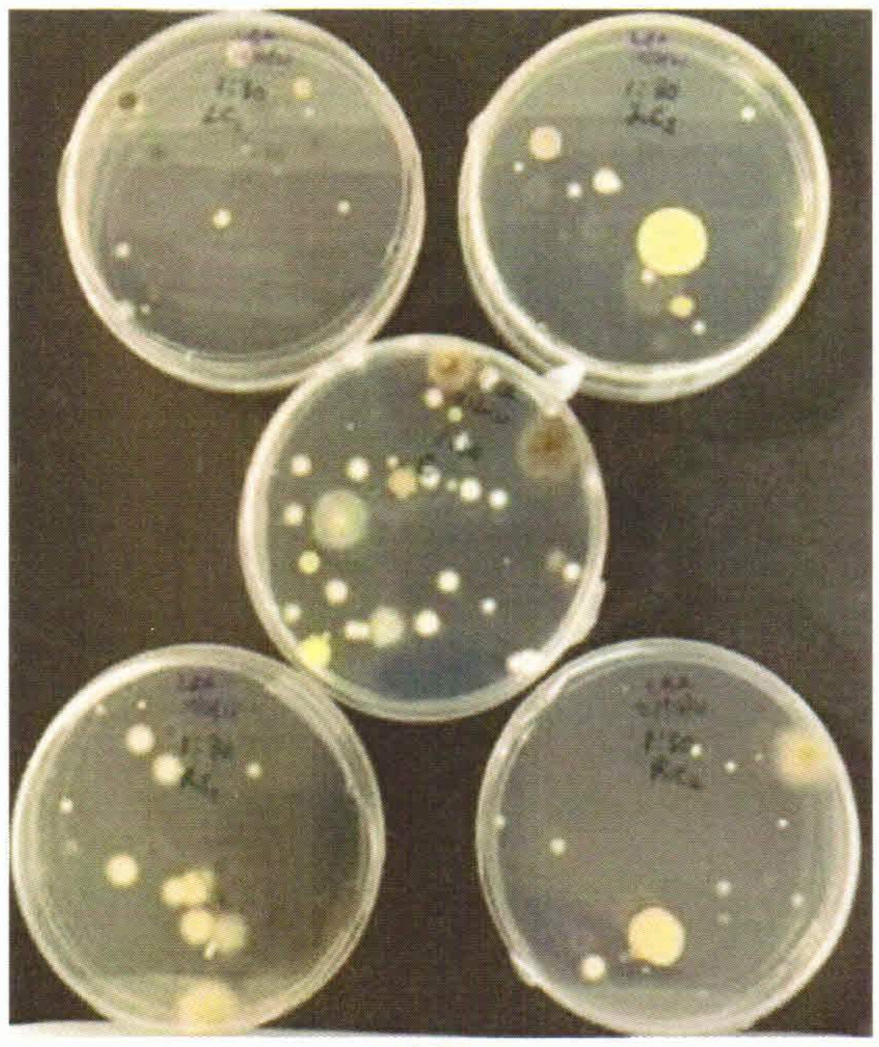

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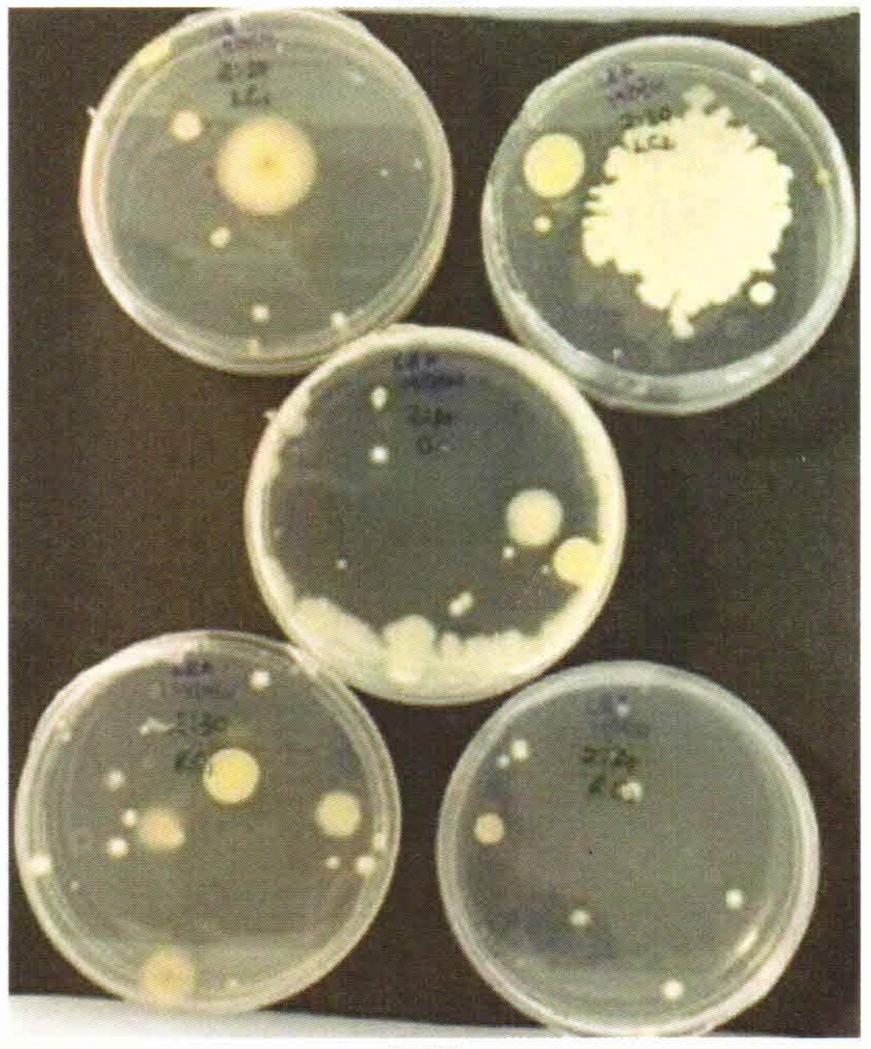

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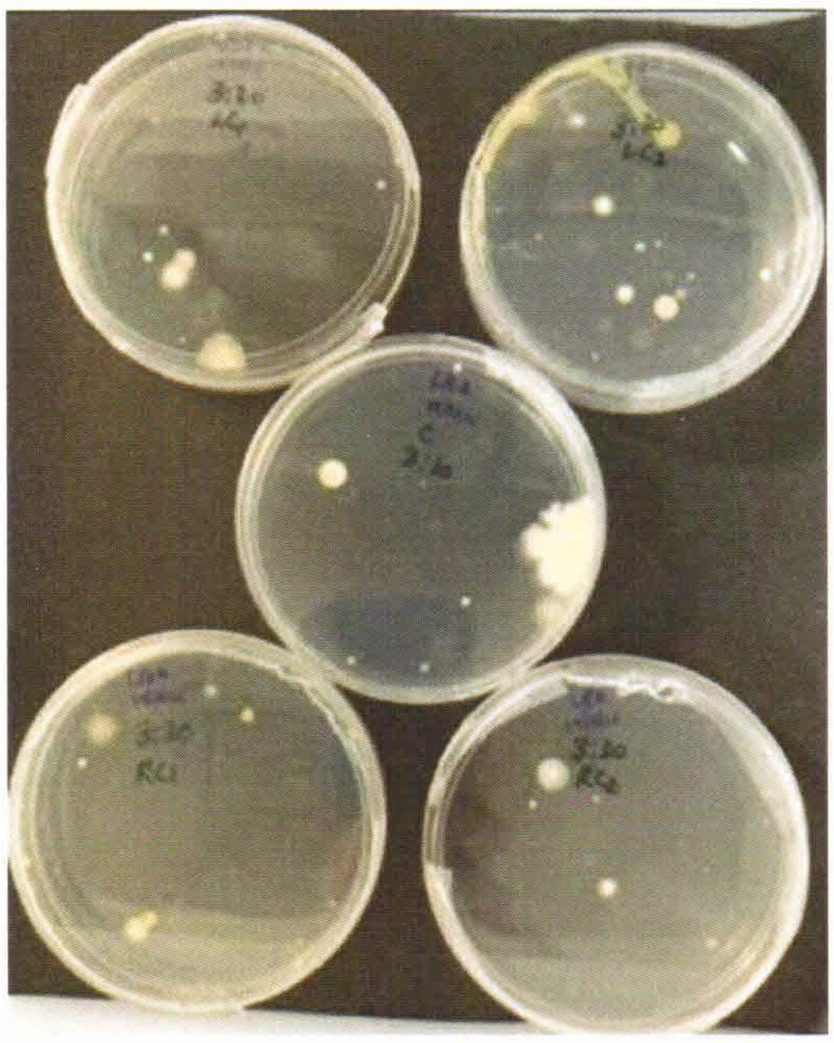

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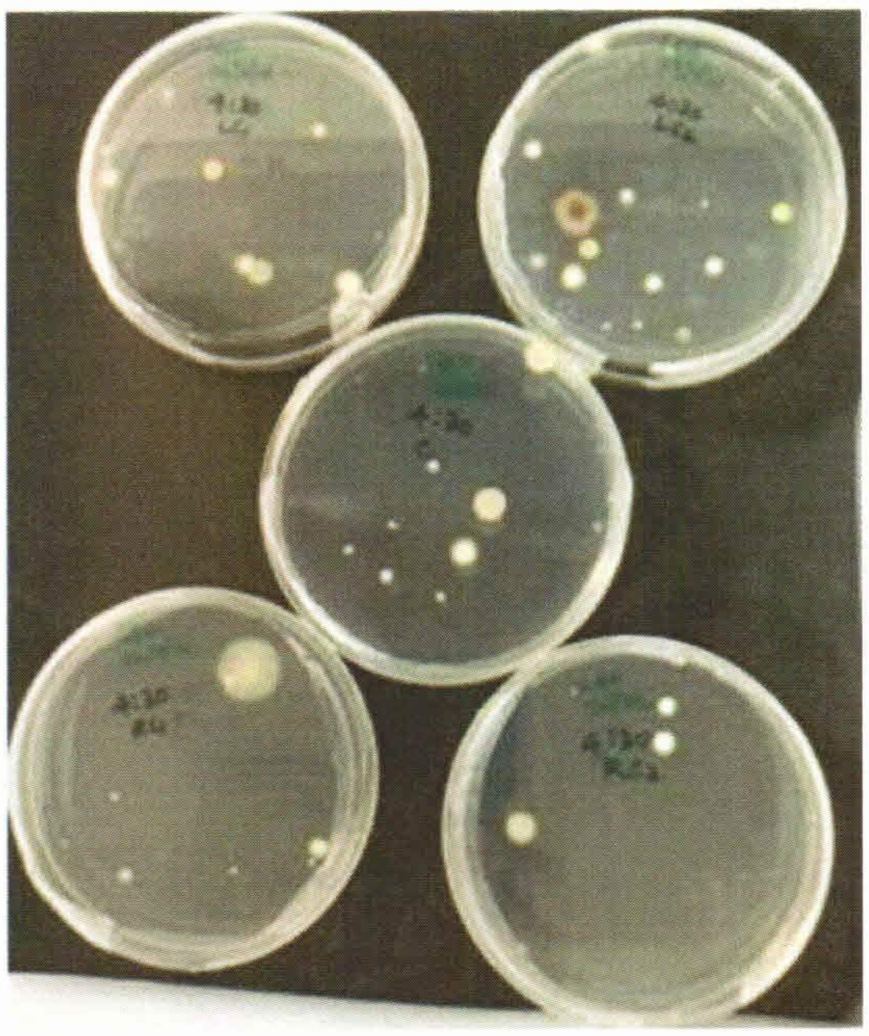

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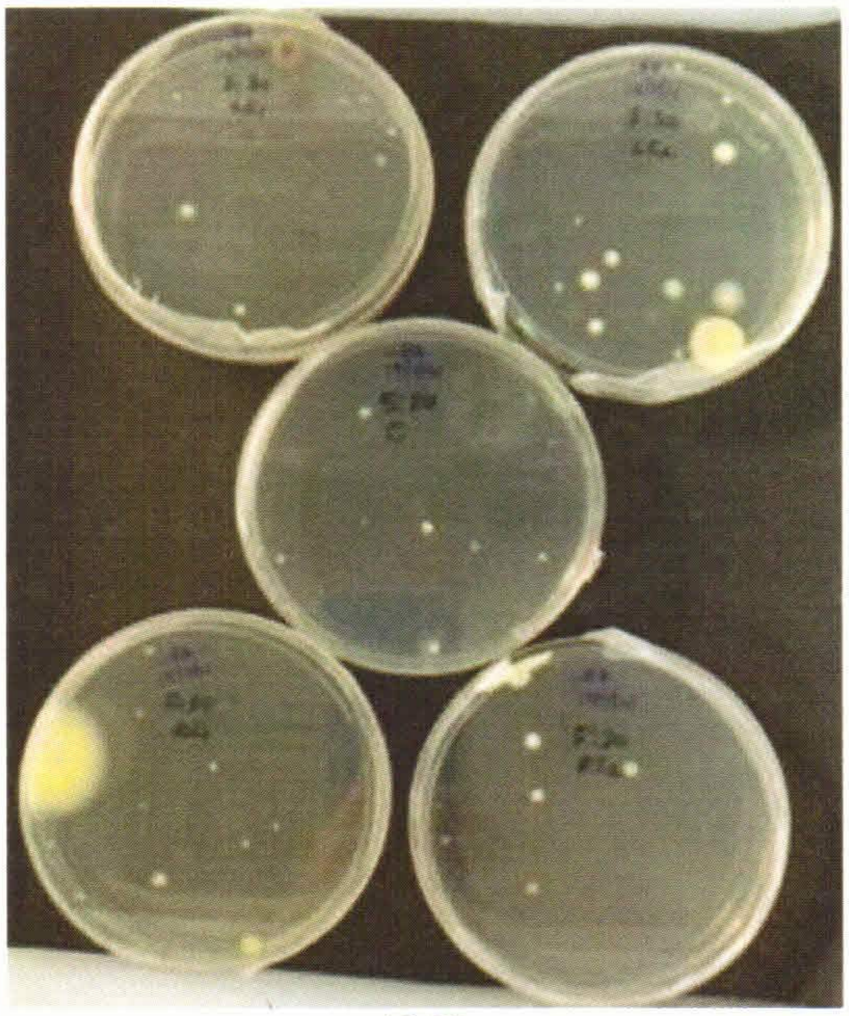

10 Hr

===End of Report===