Report No: PPCD(TP)/0117

Report

On

Testing of PPR pipes and fittings (Microbial efficacy)

Sponsored by

M/s Northern Railway
Sr. Sectional Engineering
JIND Junction
Haryana-126102

CSIR- Central Building Research Institute
Roorkee-247667
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Project No.	-	TSP-0117
Title	-	Testing of PPR pipes and fittings (Microbial efficacy)
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Principal Investigator

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Testing of PPR pipes and fittings (Microbial efficacy)

1.0 Introduction

Plastic pipes have built an excellent track record as a pressure pipe for around 50 years and is today the standard solution over conventional piping (metal and concrete) for water distribution system. Three types of plastic pipes are mainly produced in the country. These are: low density polyethylene pipes (LDPE), high density polyethylene pipes (HDPE) and unplasticized/rigid polyvinyl chloride pipes (PVC). Recently, some new plastic pipes such as polypropylene random copolymer (PPR) are introduced in the market in hot and cold water supply, offering advantages of being good heat resistance, high impact, low creep behavior and high flexibility. Polypropylene random copolymer is perhaps somewhat of surprise with its rigidity and hardness and yet low density, which results largely from its spiral molecular structure. In random PP, co-monomer units (ethylene) are arranged randomly as distinct from discrete blocks along the polypropylene long chain molecule. Because of good low temperature impact response and high softening point, polypropylene random copolymer is actively considered for pressure pipe manufacturing in hot and cold water distribution systems. Pipe lengths are joined by heat fusion, threading (with heavy pipe) and mechanical seal devices.

Doubts are often expressed on the quality of potable water especially biological growth in water flowing through the pipes. Since, PP random is relatively new piping material, their suitability for potable hot and cold water supply and satisfactory performance in end use conditions should be known to make them acceptable for large scale adaptation in the field.

M/S Northern Railway, Sr. Sectional Engineering, JIND Junction, Haryana contacted the CSIR-Central Building Research Institute, Roorkee to identify the type of piping materials and also to study the anti-microbial efficacy of pipe coated with triclosan.

2.0 Scope of work

The following scope of work is framed:

1. Identification of polypropylene random co-polymer (PPR) through Fourier Transform Infrared spectroscopy (FTIR) and Atomic force microscopy (AFM).

2. To study the anti-microbial efficacy of PPR pipes in preventing biofilming of microorganisms in the inner walls of the pipes

3.0 Experimental

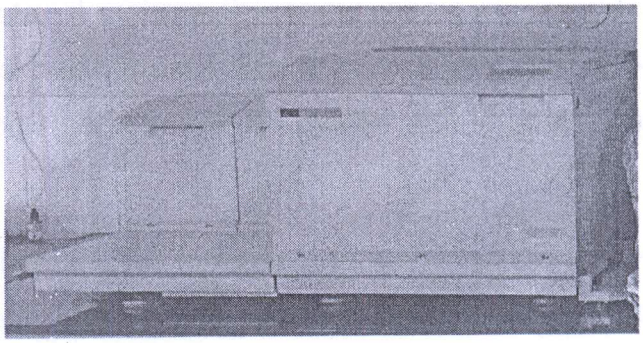
3.1 Materials

M/S Northern Railway, Sr. Sectional Engineering, JIND Junction, supplied ISI marked (IS15801-2008) 2 Nos. of three layered PPR pipe samples of 75 mm OD. (SDR 7.4, PN 16) of 1 m length. The pipe consists of outer green layer with UV stabilized, black middle layer and white inner layer with antimicrobial additives.

3.2 Methods

3.2.1 Fourier Transform Infrared spectrophotometer (FTIR)

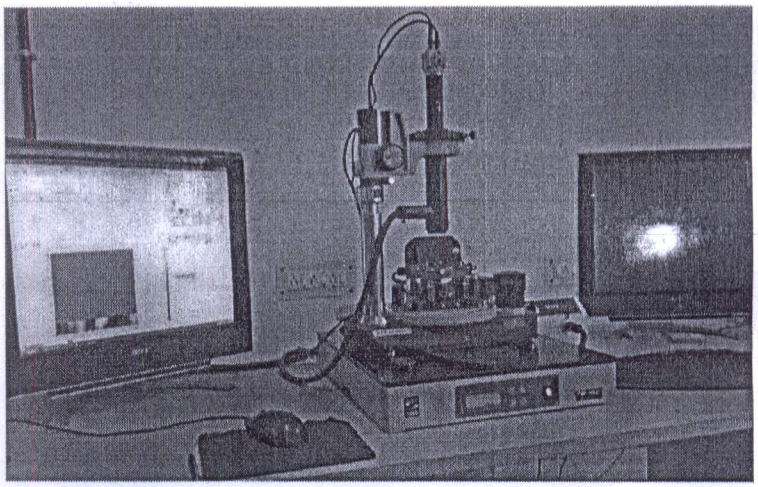
FTIR spectrophotometer (Perkin Elmer, GX Spectrum) purged with nitrogen gas was employed to collect spectra of the samples. The PPR pipe sample was microgenized and ratioed with KBr reference. The FTIR spectrum of samples was recorded at 4 cm^{-1} resolution with the accumulation of 64 scans.



Fourier Transform Infrared spectrophotometer

3.2.2 Atomic Force Microscopy (AFM)

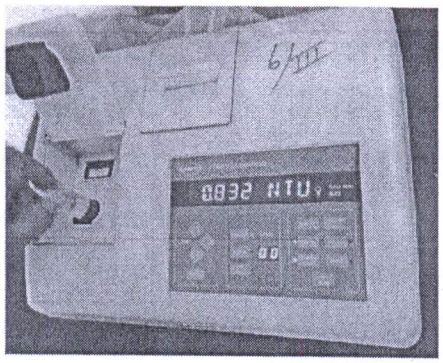
Atomic force microscope (AFM – NTEGRA, NT-MDT) was used to measure the internal morphology of PPR pipes. The sample of size 12.50 x 8.0 x 5.0 mm^3 was mounted on a metal disk which was then held magnetically under the probe. A 100 x microscope was used to view phase contrast in the samples under different magnifications.



Atomic Force Microscope

3.2.3 Turbidity

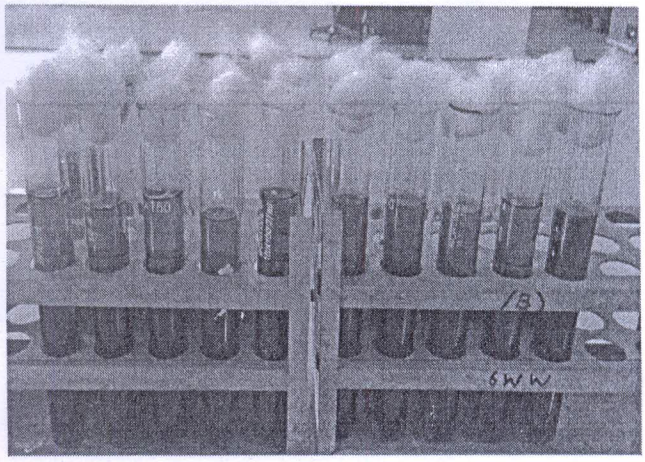
Turbidity of water stored in the pipes was measured with the help of a calibrated turbidity meter (AQUALYTIC, Germany). The water samples were poured in the glass tube and placed before the light path in the sample cell. The change in light path was recorded in terms of NTU.



Turbidity meter

3.2.4 Micro-biological test

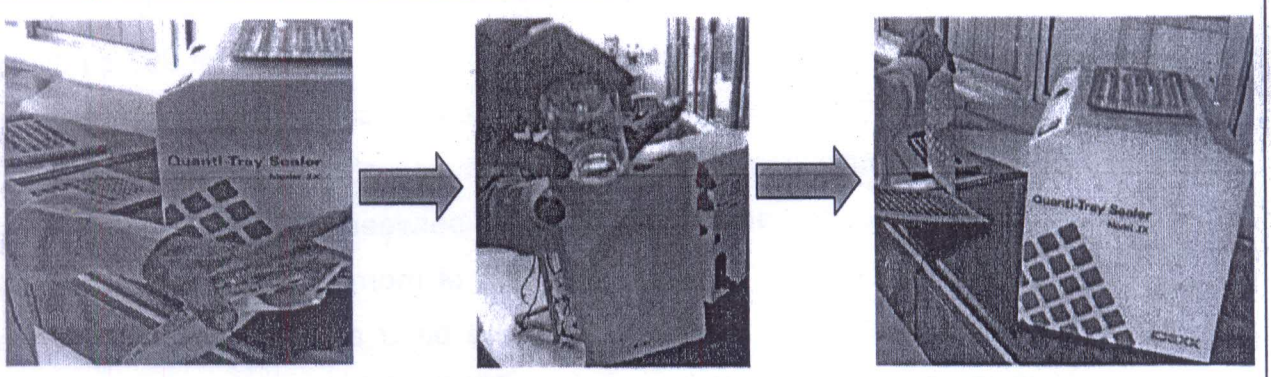
The PPR pipes were filled with tap water and stored it for 4 and 6 weeks. The microbiological test of the water withdrawn from the filled pipes after 4 and 6 weeks was carried out by the tube method according to IS: 10500-91. In this method, the inoculation of sample was carried out in the 3 tubes, each of MacConkey's broth. The sample was then incubate for 24 hrs at 37°C. The positivity in tube was determined by the change in colour from purple to yellow and accumulation of gas in the fermentation tube. The most probable number (MPN) of coliform was calculated after 48 hrs.



Micro-biological test

3.2.5 Quanti- Tray Method

This method is designed to give quantitated bacterial counts of 100 ml samples using IDEXX reagent products. It uses the same Poisson distribution statistical model that multiple tube fermentation is based upon, but it uses for more subsamples and automates the level. The limitations of multiple tube fermentation-lots of hands-on time, low counting range and broad 95% confidence limits become strengths with Quanti-Tray method. In this technique, reagent/sample mixture was added to a Quanti-Tray and sealed it in a sealer. The samples was incubated and thereafter counted the number of positive large and small wells. The most probable number (MPN) was calculated. The followings steps were involved in the determination of bacterial count.



Quanti- Tray Method

4.0 Results and discussion

Polypropylene random is an amorphous polymer (non-crystalline) having a short distance order region because of insufficiency of steric regularity. Its density lies intermediate between the calculated for completely crystalline and amorphous species. FTIR spectrum of polypropylene random piping material is given in Fig 1. Spectrum shows absorption bands at 1462, 1377, 1167, 997, 973, 898, 840 and 723 cm^{-1} in the PPR. The bands at 1167 and 973 cm^{-1} are attributed to amorphous as well as crystalline polypropylene. These bands are considered as characteristics of the propylene unit in random/block polymer. The shift of 973

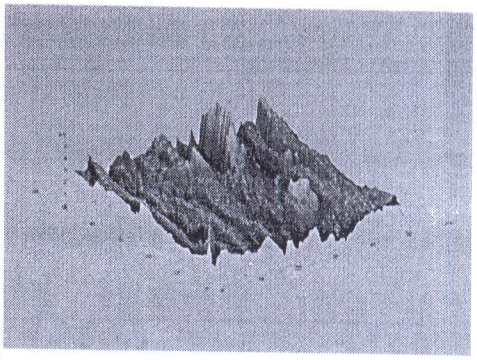
cm^{-1} from standard 975 cm^{-1} peak in PPR gives an indication on the distribution of propylene sequence in the polymer. The intensity of bands at 997 cm^{-1} is smaller than the intensity of band at 973 cm^{-1} which indicates the amorphousness of the PPR. For identification of sequence distribution of the co-monomer ethylene, the characteristic bands are usually occurred between 720 and 733 cm^{-1}. The band appeared at 722 cm^{-1} indicates insertion of more than two sequential ethylene unit in the chain. It is concluded that the band at 1167 and 973 cm^{-1} may be considered as characteristics of the $-CH(CH_3)-CH_2-$ propylene unit in random PPR. When compared with the spectrum of polypropylene reference, PPR exhibited different absorption bands showing existence of random sequences. Supportive of this, atomic force microscopy of PPR random piping material in different layers is carried out to know soft and hard domains in the microstructure. The AFM image is taken both at higher and lower magnifications (Fig 2). In the case of outer green layer, microstructure is soft and liquid like. The average roughness of grain is 644 nm. While at lower magnification ring like feature is observed. The average roughness is 34.8 nm which indicates that microstructure is smooth. For middle like layer, microstructure is soft with fibril like feature. The average roughness is 587 nm. At higher magnification, the internal structure is smooth with an average roughness of 178 nm. In case of inner layer of pipe, the microstructure is soft with a distribution of white patches (average roughness 521 nm). At higher magnification, internal structure is fluid like with an average roughness of 146.85 nm. These microstructure features supported FTIR spectra of PPR piping material.

Microbiological test of water stored in the PPR pipes for 4 - 6 weeks is carried out as per IS 10500 (Fig 3). The coliform growth in water withdrawn from water filled pipe is negligible and also similar to tap water (control) when tested by multiple tube method. After 6 weeks, the coliform growth is less than 2 MPN as against to specified limit of 10/100 ml as mentioned in IS 10500. Turbidity of water is 1.09 NTU which is also under permissible limit of IS 10500 (10 NTU). This indicates that PPR piping material does not support any kind of biological growth.

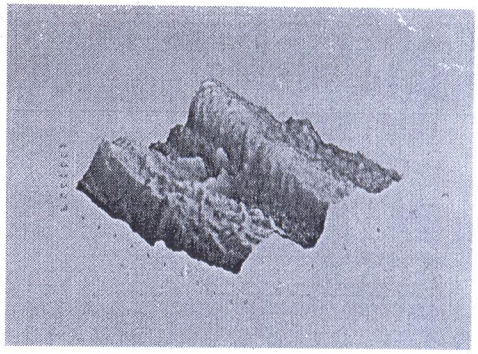
Supplement to this, quanti-tray method is also used for quantitative bacterial count of 100 ml samples using IDEXX reagent products (Fig 4). It was found that the bacteria count is insignificant compared to 200 counts of limit.

5.0 Conclusions

- On the basis of experimental results, the pipe supplied (branded SFMC) by the Northern Railway is made with polypropylene random co-polymer (PPR) as evidenced under FTIR and AFM studies.
- The PPR pipes have been found suitable against microbial growth because of anti-microbial additives present in the inner walls of the pipes. The test was conducted as per IS 10500: Indian standard specification for drinking water and also Quanti-tray method.
- The work has been carried out on the samples supplied by the party and the results reported are based on these samples.

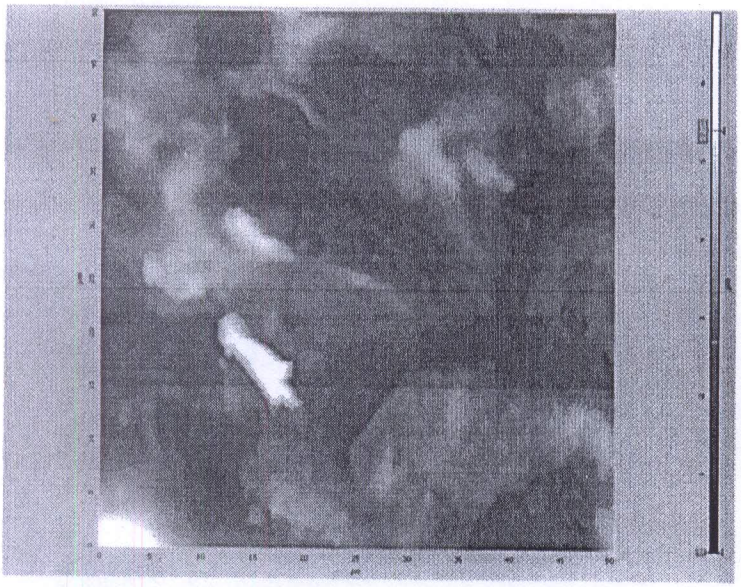


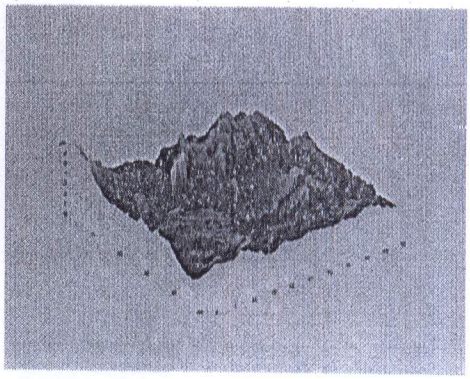
3-Dimensional view



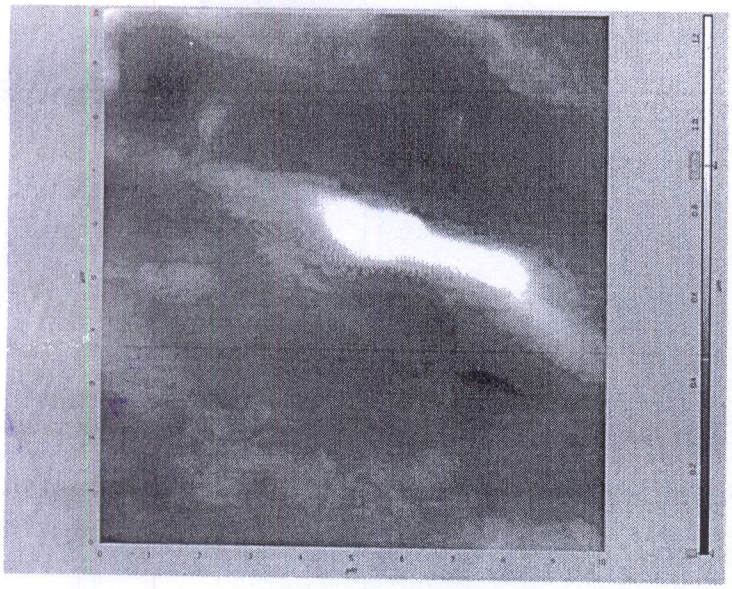
3-Dimensional view

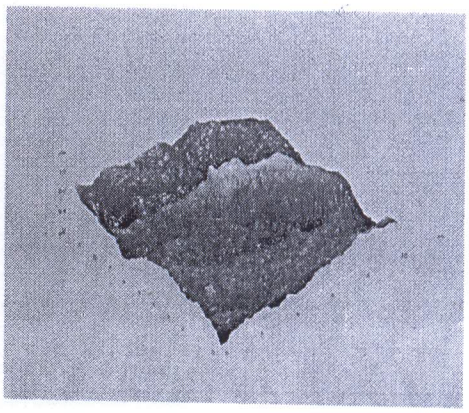
Fig. 2 (b) Atomic force microscopic images of middle black layer of PPR pipe





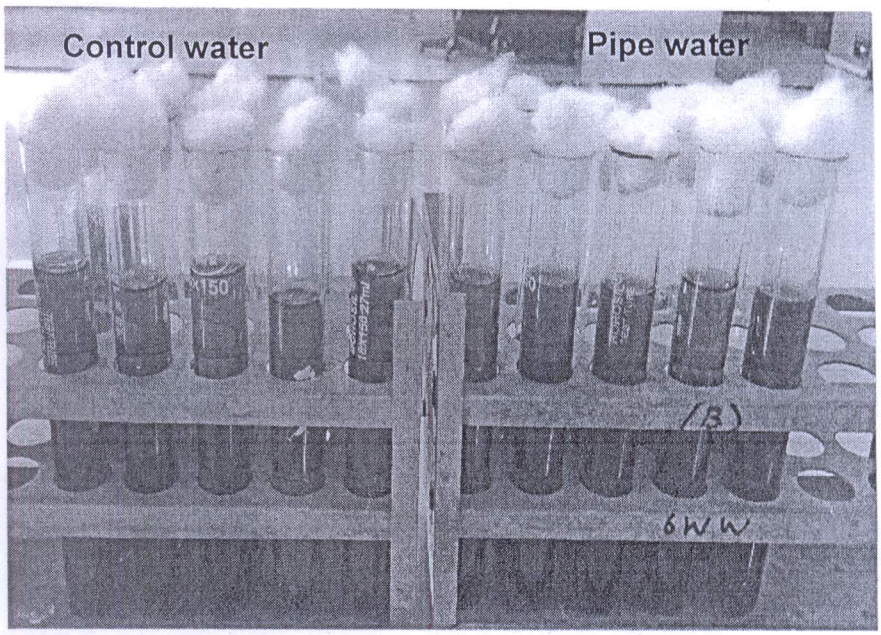
3-Dimensional view



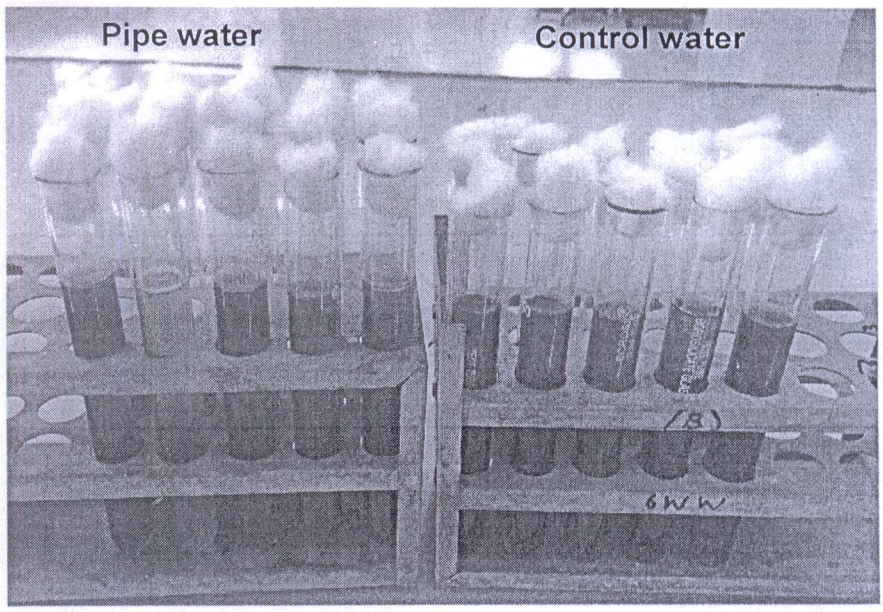


3-Dimensional view

Fig. 2 (c) Atomic force microscopic images of inner white layer of PPR pipe

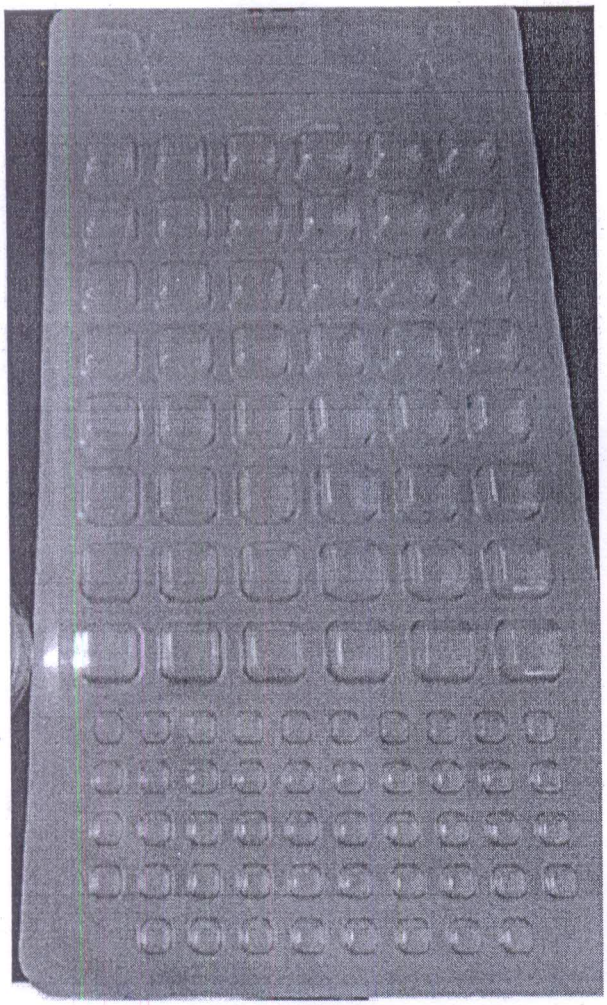


4 weeks



6 Weeks

Fig. 3 Microbial examination of water stored in PPR pipes



Control
(Tap water)

Pipe water

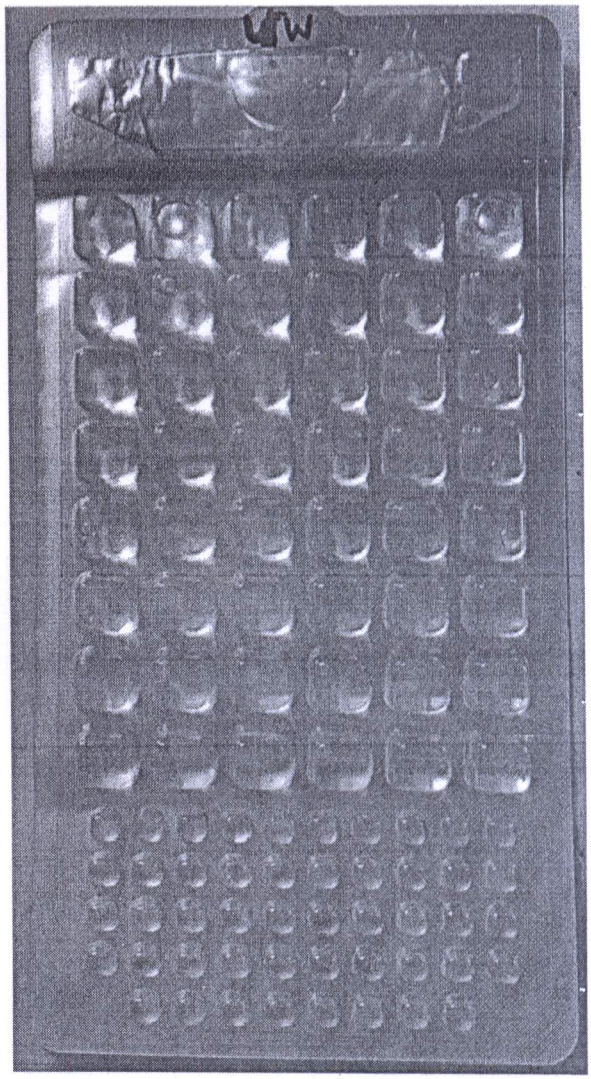


Fig. 4 Estimation of bacterial count of 100 ml sample by Quanti-Tray method