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# Review on Antibacterial, Antiviral, and Antifungal Properties of Natural Diapers and its Effect on Dermatitis

[1]Deepali Mor, [2]Sahas Bansal, [3]M. Ramachandran, [4]Pramod Raichurkar

[1]SPTM, SVKM's NMIMS University, Dhule, Maharasthra, India
[2,3,4]MPSTME, SVKM'S NMIMS University, Dhule, Maharashtra, India

**Abstract:** Diapers are the underpants worn by infants until they are potty trained, women during menses (sanitary pads), and adults in severe health conditions. This article deals with the diapers worn by infants. Diapers are multilayer invention containing absorbent layer, antimicrobial agents, protective sheets, and fasteners to fit the diaper on the infant's body. They are prepared from either naturally occurring fibers like cotton, wool, bamboo, jute, linen, etc or synthetically prepared fibers such as nonwoven polypropylene, polyethylene, polyester, nylon, etc. Diapers are of two types; the cloth diapers and the disposable diapers of which cloth diapers are more recommended. The very common problems faced by the use of diapers are diaper rashes, dermatitis. It is caused due to the moistened topsheet of diaper after the excretion of waste products. The presence of various disease causing bacteria Escherichia coli, like Staphylococcus aureus, Klebsiella Pneumonia and fungi like Candidia albicans was observed. In the present article, we are discussing about the diseases caused by the above-mentioned microorganisms and various remedies such as Silver nanoparticles, Curcumin *(Carcuma longa or Turmeric),*Zinc Oxide and Neem (*Azadirachta indica)*that shows antibacterial, antiviral and antifungal actionto prevent these diaper rashes. Later, we also added a note on the environmental aspects regarding the use of diapers and its affect on the environment after it's disposable.

## I. Introduction

Diapers, also known as nappies are the underpants consisting of the absorbent materials especially designed for the infants so as to prevent the leakage and elimination of waste products from babies at inapt places and maintain hygiene. Diapers can be prepared from a number of natural fibers such as cotton, muslin, bamboo, wool, linen, jute, etc and synthetic fibers such as non woven polypropylene, polyethylene, nylon, polyester, etc. Diapers are designed in such a way that the top sheet (facing to the infant's skin) of the diaper comprises of the antimicrobial agents to encumber or inhibit the growth of bacteria and cease its action on the baby's skin. Antimicrobial agents are anything which works against the life of the microbes or bacteria. Next lays the absorbent layers which deeply absorb urine keeping the upper layer (top sheet) dry. This prevents the growth of many rashes causing harmful bacteria and micro-organisms. Finally lays a back sheet (outer layer) which is made up of plastic or rubber type of material to provide an advanced leak protection. These layers are attached one after the other and different types of fasteners are extended. The fasteners used may be plastic tapes, Velcro, hook and loop, button and loop etc. The reference view of the general structure a modern diaper is shown in Fig.1. Some diapers may also include special type of fragrances in order to mask the foul smell of the waste products[1]. The only drawback of diaper is that they cause various skin problems. Nowadays, the diapers not only contain the antimicrobial agents but also the anti-rash lotions in the top sheet itself. The long time no change of diaper or due to the prolonged contact to wetness leads to certain skin disease such as

dermatitis, infections, etc due to the presence of certain bacteria like Escherichia coli, Staphylococcus aureus, Klebsiella Pneumonia and fungi like Candidia albicans, etc. These diseases are the severe inflammation or abrasions of the skin. Moreover, the skin of an infant is far more sensitive to various allergic reactions to diaper, bacterial infections and yeast infections. In this work, we are giving an overview study of different methodologies which will reduce the bacterial activity and inhibit its growth. Referring to Fig.2 these antibacterial agents include Silver nanoparticles (Ag), Curcumin (*Carcuma longa*),Zinc Oxide (ZnO) and Neem (*Azadirachta indica*). Disposable and cloth diapers are the two types of diapers which are used by the parents. Cloth diapers are the reusable diapers whereas disposable diapers are the throwaway diapers or one time use diapers. Besides all these, the production and use of diapers cause a number of problems to the environment[2]. According to certain studies carried out, diapers are proved to use much of the non-renewable resources of the earth, causing manifest impact on the global warming along with land or soil pollution due to the disposable of one time use diapers.

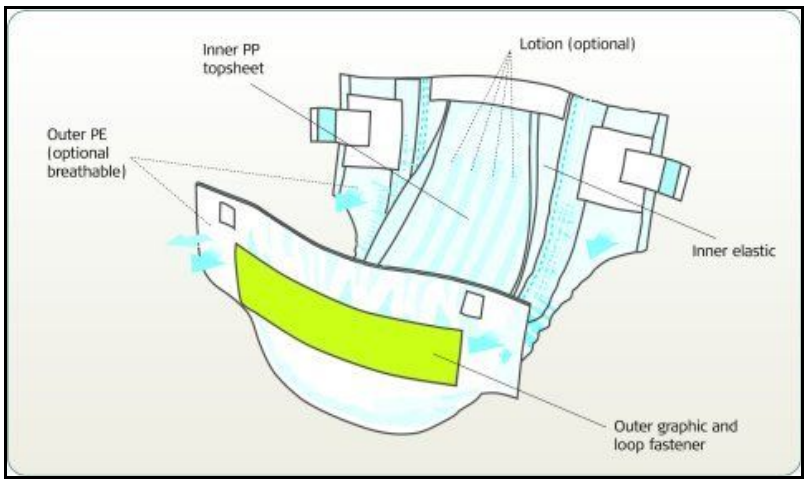


**Fig.1 General structure of Diaper**

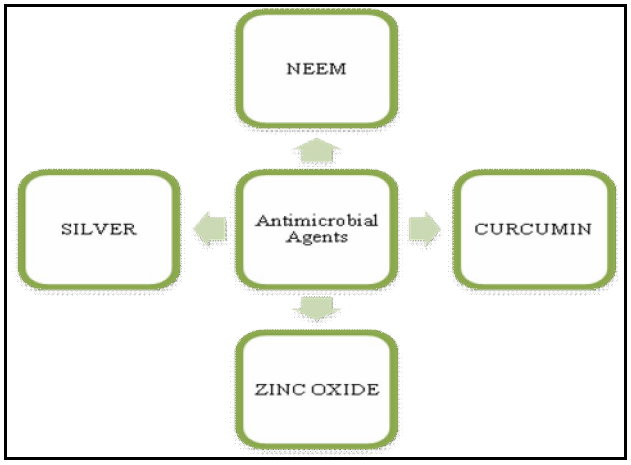


**Fig.2 The four Antimicrobial Agents**

## II. Various Diseases and Their Causes

As we discussed earlier, the prolonged contact to wetness gives rise to certain skin inflammations which if neglected may lead to severe skin conditions and reactions. The various skin problems include dermatitis, allergic reactions, yeast infections, bacterial infections. Dermatitis is caused by some irritant, recognized by the redness or soreness of the skin. The yeast infections are caused by the Candida albican species of fungi. It is developed if dermatitis is not treated within a sufficient time period. The allergic reactions are caused due to the allergic factor present in the diaper. This case is less likely to happen. It happens only if the infant's skin is sensitive to any of the material used in the diaper. The bacterial infections are caused if the harmful bacteria such as Gram Positive Staphylococcus aureus, Escherichia coli and Gram negative Klebsiella

Pneumonia are present. These are the most common bacteria and infections. The other less common infections include Proteus mirabilis, enterococci and Pseudomonas aeruginosa.

**III. Action of Curcumin Powder in Diaper**

Talking about Curcumin, an active chemical constituent of turmeric (rhizome) which is obtained from the plant *Carcuma longa* (Turmeric in common)have been known since years not only for its antimicrobial, antiviral and antifungal properties but also for its antioxidant, anticancer, anti-inflammatory properties. It has been commonly used in almost every part of the world. Curcumin has been widely used by the textile industries as natural dye due to its yellow color. Besides, dying, it also enhances the antimicrobial activity of the fibers such as cotton and wool. And it has proved to inhibit nearly 35% to 45% of the harmful bacteria namely Staphylococcus aureus and Escherichia coli.Some studies show that extracts of *Carcuma longa* including Curcumin were found to reduce the bacterial growth of nearly 13 bacteria such as Vibrio harveyi, V. alginolyticus, V. vulnificus, V. parahaemolyticus, V. cholerae, Bacillus subtilis, B. cereus, Aeromonas hydrophila, Streptococcus agalactiae, Staph. aureus, Staph. intermedius, Staph. epidermidis, and Edwardsiella tarda. Not only this, it also showed its significant action on isolates of bacteria such as Helicobacter pylori and Klebsiella pneumonia. Curcumin showed a very momentous antviral activity against certain viruses such as Human immunodeficiency virus(HIV), Swine Flu (H1N1 virus), Influenza virus, Herpes simplex virus (HSV), Flock house virus (FHV), Respiratory syncytial virus, etc. Moreover these viruses did not develop resistance for Curcumin they developed it for other antiviral agents. Curcumin also showed the potential of controlling fungal growth of certain bacteria (Ex: Candida albicans) and the spoilage caused due to it. It showed its action against various strains of Candida. Curcumin when used in alliance with other antimicrobial agents or antibiotics, it showed an enhanced activity. Its use with chitosan, aloevera, silver nanoparticles when charged on wool or cotton showed improved action against microorganisms. Similarly, the use of Curcumin with antibiotics such as Ampicillin, Oxacillin, and Norfloxacin showed greater effect against bacteria such as Staphylococcus aureus and Escherichia coli[3]. The silver nano composites were encapsulated with the Curcumin to enhance the antibacterial properties against various bacteria. Hence, the fabrication of silver nano particles along with Curcumin might prove to be a promising composite for the various uses in the diapers, wound dressing fabrics as well as antimicrobial packaging materials with a superior antimicrobial activity[4]. The use of Curcumin is restricted because of its poor bioavailability. Hence, so as to overcome this issue it has been used in combination with other elements which will improve its bioavailability and give better results. Besides to enhance the bioavailability of curcumin in itself i.e without the use of any other elements, certain studies shows that Curcumin nanoparticles have remarkable resuts. The nanoparticles of Curcumin of size 2-40 nm showed better bioavailability than the normal Curcumin powder. Also, the heated extract of Curcumin gives us prominent results.All the above studies gives us a fair idea about the use of Curcumin powder and its derivatives in diapers for an improved diaper activity and reduced skin problems due to the prevention of growth of various microorganisms- bacteria, fungi, etc. Fig.3 depicts the Turmeric rhizome and Curcumin powder.

**Fig.3Turmeric and Curcumin**

**IV. Action of Silver Nanoparticles in Diapers**

The fabric used for diaper is treated with certain chemicals or naturally occurring substances which shows antibacterial activity against the certain bacteria produced in the area. These materials usually include metals salt solutions, quaternary ammonium salt solutions, etc which may be toxic to the babies. Here we discuss the effect of the antibacterial properties of nano-sized Silver (Ag) colloidal particles on the nonwoven Polyethylene/Polypropylene. Three types of nano-sized Silver colloidal solutions in different concentrations were used. They are Ag ions in water, Ag ions in ethanol and Ag-S composite in ethanol. Of which the Ag-S

(Silver Sulphur) Composite in ethanol base was found to be most effective even in its lower concentrations. These three mixtures in different concentrations was applied to the nonwoven PP/PE and were treated with 3 different bacteria that is Gram-negative Klebsiella pneumonia and Gram-positive Escherichia coli and Staphylococcus aureus and observed after different time periods. The studies revealed that the water based nano-silver particles were able to reduce the concentration of Gram-positive bacteria S.aureus and E.coli but it couldn't show its antibacterial activity against Gram-negative bacteria K.pneumonia even in its higher concentrations. The ethanol based Ag ions showed a very good antibacterial activity on the Gram Positive bacteria even in its lower concentration, but in order to reduce the concentration of the gram negative bacteria, it required a higher concentration.The ethanol base of the Ag-S composite in its lowest concentration not only reduced the number of Gram positive bacteria (S.aureus, E.coli) but also showed its activity on the Gram negative bacteria (K.pneumonia) which are usually stronger than Gram positive. Though Sulphur is a toxic material but when reacted with Silver, it did not show any toxic activity; rather the antibacterial activity of Silver ions was enhanced due to the addition of Sulphur. Hence, we can conclude that the Ag-S composite in the ethanol base is proved to be a very good antibacterial, non toxic disinfecting agent. Also, the silver nano composites show a superior antimicrobial activity as compared to the bulky Silver due to a larger surface area and its larger fraction which allows the nano particles to penetrate into the bacteria and prevent its replication [5].Fig.4shows the structure of Ag, Ag nanoparticles and its solution.


**Fig.4Ag nanoparticles & solution**

## V. Action of Zinc Oxide in Diapers

Zinc Oxide (ZnO) is widely known for its Catalytic property and has been used as antimicrobial agent in many creams, lotions, cosmetics, etc due to its non-toxic and biocompatible nature[6]. ZnO is a great UV absorber that is it has the property to absorb light and protect the skin from harmful Ultra violet rays and act as Sunscreen [7].Bamboo salts containing Zinc had an anti-inflammatory action on the skin diseases. ZnO has made its wide application in the field of Science-biology, medicine and physics[8]. In addition to this, it has been used to treat various skin problems in infants caused due to diaper rash. ZnO shows better results when used in its nanosize. The ZnO nano particles help increasing the surface area with an improved antimicrobial activity. ZnO nano particals is a novel framework for enhancing the therapeutic potential in the health care applications. A study shows that, ZnO nano particles induced in the baby diapers will enhance the diaper activity and reduce the chances of skin problems due to its catalytic reactions. Similar to the applications of anti rash lotions in the topsheet of the diapers as shown in some US patents[9], the use of ZnO nanoparticles impregnated in the topsheet of diaper can improve the diaper activity. ZnO nanoparticles were found to inhibit the growth of the pathogens and microbes such as Gram-negative Klebsiella Pneumonia and Gram Positive Staphylococcus aureus, Escherichia coli. 100% woven cotton when treated with ZnO nanoparticles showed about 93% inhibition against the bacteria such as Klebsiella Pneumonia and Staphylococcus aureus[10]. Moreover, ZnO nano particles did not show any adverse effect on the basic properties of the fabrics such as tensile strength, elongation, etc. Besides, ZnO is also an inexpensive material to use it in diapers. Fig.5 shows the Zinc Oxide Powder in its pure form.

**Fig.5 Zinc Oxide Powder**

## VI. Action of Neem Powder in Diapers

Neem (*Azadirachta indica)*, the most known antimicrobial plant in the world has been widely used over decades to cure and eliminate skin problems. The powder of the Neem leaves was applied on the infections to treat the infections. Similarly, the powder of the Neem leaves applied on the babies reduced the rashes and prevented other skin problems. Practice of such methods proved useful and showed no side effects on the skin of the user. Moreover, it kept the skin fresh and prevented the action of pathogens causing skin infections. The antiviral activity of Neem prevents the spread of infections caused due to virus. Studies shows that the ethanol extracts of alcohol resulted in a striking antimicrobial action which is demonstrated in Table.1

**Table.1**

| **Organism** | **Inhibition Zone (in parts per million)** | | | |
|---|---|---|---|---|
| | **1000 ppm** | **2000 ppm** | **3000 ppm** | **4000ppm** |
| ***E.coli*** | 6.7±0.27 | 8.3±0.24 | 10.7±0.16 | 12.7±0.14 |
| ***Klebsiella*** | 6.5±0.21 | 8.7±0.23 | 10.7±0.15 | 12.4±0.24 |

These are the usual microbes found in diapers, which causes the diaper rashes and other skin issues [11].All the parts of the Neem tree- roots, leaves, barks, and seeds are commonly used for the therapeutic purposes. Neem oil consists of tetranortriterpenoids, triglycerides, nimbin, nimbinin, nimbidinin, etc., which helps in suppressing the growth of the disease causing microbes such as E.coli and Staph. aureus. Besides this, Neem leaf powder is also used as a natural adsorbent in textile industries to remove impurities. Plasma surface modification technique is used by the textile industries to modify the physical and chemical properties of the fabric surface. The bioactive Neem oil can be used to generate the antimicrobial activity in plasma treated cotton fabrics [12]. Fig.6 shows the structure of Neem leaves and its powder.

**Fig.6Neem leaves and its powder**

## VII. Environmental Aspects related to Diapers

The use of Diapers contributes the environmental footprints in certain ways. Cloth diapers as well as the disposable or one time use diapers includes usage of energy, water, and land which accounts for the various environmental problems such as land/soil, air, water pollution, etc. Many confusing conflicts have been occurred regarding this issue. The disposable diapers use more of natural resources as compared to the reusable diapers and also use land after being discarded and causes pollution. At the same time, also the reusable diapers involve the energy consumption, water usage and toxic detergents used to wash them. Washing them with the other load of clothes and drying them outside in the sun and using them again, reduced the global warming

impact by almost 40%. Chlorine bleach used for papers used in manufacturing of disposable diapers and by some diaper services for cotton cloth diapers had adverse effects on the human health problems including cancer as it produced a persistent toxin called "dioxin". Hence, use of chlorine should be totally avoided. The latest biodegradable disposable diapers have a little less impact on the environment unless they are packed in the plastic bags while discarding. Hence, we can say that the reusable as well as disposable diapers affect the environment in their own ways of which the cloth diapers cause bit less damage to the environment. The Life Cycle Assessment of the USA carried out certain surveys regarding the use of disposable diapers from which it concluded the sustained use of resources for the production of diapers[13]. It helps us to understand the possible ways of how any product that is manufactured and used by the consumers affect the environment. Not only this, but the impact on nature or environment also be due to the use of synthetic antimicrobial agents[14]. It is true that the synthetic antimicrobial agents are beneficial, efficient and much more durable than the natural ones but at the same time, they are linked with side effects as well as non toxicity and harmful effects on the environment.

## VIII. Conclusions

Well, taking into consideration all the above methodologies and other environmental aspects, we come to a conclusion that Curcumin and Neem powder are the best antimicrobial agents as they show not only the antimicrobial activity but also the antiviral, anti-inflammatory action on Dermatitis and other skin diseases. Also these drugs are cost effective when compared to Zinc oxide and Silver and obtained from the renewable sources i.e. plants and trees. Although Ag and ZnO show a great antimicrobial activity but they are the non-renewable sources obtained from mines. Also, they may prove to be hazardous for the environment to some extent if used in an unsustainable manner. Besides, using Curcumin and Neem improves the antimicrobial activity and adsorbent potential of the fibers used for diaper making. Therefore putting more emphasis on Curcumin and Neem certain more research needs to be carried out in order to make diapers containing these natural, renewable drugs so as to provide the upcoming generation with 100% natural diapers. These diapers will prove beneficial for not only the infants but also it will take care of the sustainable use of certain non-renewable resources and leave less or neglible environmental footprints.

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