Proceedings of the 7th WSEAS International Conference on Mathematics & Computers in Biology & Chemistry, Cavtat, Croatia, June 13-15, 2006 (pp45-53)

Study of the Health Effects of Chromium Rollers Used in Cotton Roller Ginning Industries and Development of an Alternative Ginning Process

GURUMURTHY VIJAYAN IYER,
MNM Jain Engineering College,
36, Venkatesh Nagar Main Road,
Virugambakkam, Chennai-600 092,
INDIA

http://www.vijayaniyer.net

NIKOS E. MASTORAKIS
WSEAS European Office
Agiou Ioannou Theologou 17-13,
15773, Zografou, Athens,
GREECE

http://www.wseas.org/mastorakis

Abstract:- This review paper realizes the hazards of chromium contamination and pollution caused by the use of Chrome Composite Leather-Clad (CCLC) rollers commonly used in cotton roller ginning industries and attempts to eliminate the chromium contamination and pollution during the cotton ginning process. The cotton roller ginning process is the mechanical separation of cotton fibres from their seeds by means of one or more rollers to which fibres adhere while the seeds are impeded and struck off or pulled loose. When the seed-cotton is ginned, due to persistent rubbing of CCLC rollers over the fixed knives, the ginned lint cotton adsorbs about 143 to 1990 mg/kg (ppm) as total chromium of trivalent and hexavalent forms and the cotton products carry with it of about 17 to 250 mg/kg (ppm) of chromium which according to Indian Standards (MOEF-157, 1996) for yarn and fabrics, should not be more than 0.1 mg/kg (ppm). Toxic effects are produced by prolonged contact with airborne or solid or liquid chromium compounds even in small quantities because of their properties viz. carcinogenecity, mutagenecity and corrosiveness. Traces of Cr (VI) are found even in analar grade trivalent compounds and complications do arise due to reduction in nature of these traces that affect the organic tissues of the body. To offset the unsafe chromium contamination and pollution from cotton ginning industries, chrome-free rubberized cotton fabric (RCF) rollers or eco-friendly rollers both for laboratory and commercial studies have been designed, fabricated and experimented on a special-built gin roller experimentation device (GRED) and double roller (DR) gins. These rollers are covered with packing-type roller covering material made from multiple layers of cotton fabric bonded together with a rubber compound. On the basis of the design and development of various rollers with subsequent performance evaluation studies, chrome-free RCF roller has been demonstrated with reference to techno-commercial and eco-friendliness in ginning industries. This pollution-free and chrome-free RCF rollers were found successful in ginning out seed-cotton in an environment friendly way, while maintaining high ginning rate potential, cotton technological parameters of lint, yarn and fabric properties. The ginneries have been tested commercially and found better in all aspects with reference to cotton technological parameters, dye-catching properties, physical and chemical properties. It could be successfully used commercially as an improved alternative in cotton ginning industries for the cleaner environment with benefits to society, industry owners, traders, workers, employees and the Government.

Key-words: chromium, rollers, cotton lint, rubber canvas , ginning

1 Introduction

This research paper realizes the hazards of chromium contamination and pollution caused by the use of dust-producing grinding of chrome composite leather-clad (CCLC) rollers commonly used in cotton roller ginning industries and attempts to nullify this problem during the cotton ginning. The research has been carried out with the following objectives:

- To identify and study the environmental problems existing with the present chrome

rollers employed in cotton roller ginning industries.

- To design and develop an eco-friendly chrome-free roller and evaluate its performance with particular reference to environmental and techno-commercial aspects in ginning industries.

With the author's research background and practical experience in ginning and textile industries, present study is attempted to eliminate this problem to the great extent at the source itself, through a suitable design and development of an eco-friendly, pollution-free chrome less roller for cotton roller gins. An eco-friendly roller ginning process has been developed for replacing conventional CCLC roller ginning process to eliminate the chromium contamination and pollution from cotton roller ginning industries so as to meet the requirements of environmental standards while maintaining high quality spun yarns and woven fabrics meeting the international standards.

The roller constitutes an important element of roller gins. Until 1940, only Walrus animal hide was used as roller covering material in USA and UK. Later on due to the non-availability of *Walrus*, these countries did not allow this type of hides to be used and obsolete these roller gins. Sheep and Buffalo chrome tanned hides, were used as substitutes in the roller ginning machines, though the *interfibrillary action* is not satisfactory compared to walrus hides. The roller materials *viz.*, ordinary leather, newspaper, corkboard, and coconut coir were also tried, but have not been found suitable. Since 1940, *chrome composite leather-cladding (CCLC)* material has been under use for making rollers of roller gins till now in India, Africa and Egypt. The CCLC rollers have not been used in USA and UK, since many years. Figure-5 represents countries using CCLC roller ginneries in the world.

The work presented in this article is intended to identify the environmental and health-related problems faced when CCLC rollers are used. Some experimental results of chromium analysis and relevant Indian Standards, the concentration of respirable and suspended particulate matter in some samples collected randomly are presented. Health survey observations and cotton technological reports of eco-friendly lint and chrome-contaminated lint are presented for assessing the hazards of chromium contamination of lint, yarn and fabrics and air pollution problems due to CSD. After realizing the hazards of chromium contamination in lint cotton, seed, yarn, fabric and textile effluent and air pollution problems due to chrome specific dust in ginning and textile environments, there is a need to eliminate contamination and pollution due to chromium at the source in the cotton ginning process used by roller ginning industries in India, Africa, Tanzania and Egypt. Suitable eco-friendly roller ginning process to eliminate this unsafe chromium contamination and pollution in the environment has been presented in this research review paper. An extensive and exhaustive study was undertaken for the design and development of eco-friendly, pollution-free, chromeless, rubberized cotton fabric (RCF) rollers to modify the present conventional CCLC rollers.

2. Problem Formulation

The roller gin is an outgrowth of the ancient *Hindu Churka* gin, the first record of which goes back to about 800 BC, although the two gins differ in principle of operation. The ginning of seed-cotton was practiced in a novel way in the home of the world famous *"Decca Muslin"*. The contaminants like leaves, stalks and capsules were first removed by hand from seed-cotton and then the fibres were combed by using the *jaw of the bolee fish*, the teeth of which being small, curved and closely set, acted as a fibre comb to remove the minute particles of extraneous matter. After combing, the lint cotton was separated from the seed-cotton by placing the combed ends on a smooth board (made of *chaltha* tree) and then rolling a pin backwards and forwards, in such a manner as to separate the fibres without crushing the seeds (Townsend J.S. Walton T.C. and Martin J. , *1940*). Several types of primitive roller gins were developed during the nineteenth century, but none of these was found suitable. The mode in use till date was the one patented by *McCarthy* in 1840 (Gillum, N., and Marvis, *1964)*.

2.1 Description of CCLC Rollers

The roller is the major component of Double Roller (DR) gins. The gin roller length varies from 1025 to 1148 mm with a diameter varying from 178 to 180 mm suitable for operation. The roller consists of 78 to 80 washer disks. Each washer disk is 180 mm in diameter and 1 mm thick and has 18 CCLC flaps stitched and bonded together (Vijayan Iyer, G., ***1999***).

2.2 Environmental Impacts of Rollers

Environmental impacts of CCLC rollers are assessed from the pollutants *viz.*, *cotton dust* and *chrome specific dust* (CSD) in the mill atmosphere. Their sources and health effects are briefly described below. The *cotton dust* released in the ginning process is a complex and variable mixture of cotton fibres, undeveloped ovules, cotton plant debris including twigs, bract and *pericarp* particles left after the ginning process together with soil particles, bacteria, fungi and residues from pesticides. Due to the persistent rubbing action between CCLC rollers and stationary knives in ginning machines, they are wearing out constantly and exorbitantly contaminating the ginned lint cotton with chromium and gets permanently coated during the ginning process. CSD production during this process is the major environmental chromium contamination and pollution problem from roller ginning industries. Lint cotton and cotton dust are the adsorbents of chromium from CSD emission. Thus, chromium is adsorbed in lint cotton, spun yarns, woven fabrics in macro level.

Chromium in CSD and contaminated cotton products acts on human in three ways, *viz.*, (1) local action as dermatitis or absorption through skin, (2) direct inhalation and (3) ingestion or absorption into stomach (Morton Lippman, 1991). Toxic effects are produced by prolonged contact with airborne, solid or liquid chromium compounds even in small quantities because of their properties *viz.*, carcinogenecity, mutagenecity and corrosiveness (Sujana, M.G., *et.al.*,1997). Complications do arise due to the reducing nature of these chromium traces that affect organic tissues of body.

The air pollution due to CSD and cotton dust, which is responsible for synergistic (augmentative) health complications of chromium based diseases and byssinosis diseases on ginning industry workers. Almost most of the mills in India *are not provided* with dust control systems. Nor they provide personal protection devices to the workers. It is mentioned that the ginning industries are located in and around cotton growing areas and employ women in the age group of 21 to 40 years for *menial jobs* and male workers in the age group of 18 to 50 years. The women often come along with their *children* for performing their jobs, like (i) feeding seed-cotton (or *kapas*), (ii) collecting the lint cotton, seed and floor sweeping, (iii) cleaning and grading the seed-cotton and (iv) light activities. The children are exposed directly to CSD. The health effects and reports of the workers has not come out into public, because (i) almost all the workers are not in regular employment, (ii) the cotton ginning industry functions seasonally for 6-8 months in semi-arid zones and 8-10 months in rain fed areas in an year, (iii) the workers are reluctant to go for their medical checkup because of their negligence and fear and (iv) they are economically not sound enough to go for their medical treatments. Based on the environmental impacts of CCLC rollers in roller ginning industries, the first part of the present study pertains to assess environmental chromium pollution during the cotton ginning process.

3 Materials and Methods

Studies related to size reduction of CCLC rollers were conducted from the two ginning industries situated at Bailhongal (Karnataka) and Sendhwa (Madhya Pradesh). Roller

wearing and compaction rate study were conducted in roller ginning industries at Bailhongal for the cotton seasons 1996-1997, 1998-1999, 2000-2001. The roller gins are adjusted using gauges / spacers as per the CIRCOT standards (Vijayan Iyer, G. and Parthasarathy, M.S.,*1993).* Gin operation, repairs and maintenance including regular grooving operations were performed as per CIRCOT standards (Vijayan Iyer,G. 1999) .

To study environmental chromium pollution and contamination levels from roller ginning operations, an exhaustive study was made covering four sites each having a large number of ginning industries approximately 300 numbers, namely, Guntur, (*Andhra Pradesh),* Sendhwa *(Madhya Pradesh),* Bailhongal *(Karnataka)* and Surendranagar *(Gujarat)*. Since, all other industries have been following the same trend and methods, these were expected to provide fairly a representative data. The experiments, field trials and field survey have been conducted in the chosen sites. Samples have been collected from the study areas to characterize and assess chromium pollution. Atomic Absorption Spectrophotometers (AAS) (Models-GBC-902 and AAS-3300) were used for analysis of collected and prepared samples as applicable for the total chromium analysis. Samples have been analyzed at Centre of Mining Environment, Indian School of Mines, Dhanbad and Eco-Textiles Laboratory, Mumbai. Some of the samples for environmental analysis were also tested in Central Pollution Control Board, (CPCB) Delhi. Cotton technological tests were carried out in Central Institute for Research on Cotton Technology (CIRCOT), Mumbai. Laboratory ginning studies on rollers were conducted in CIRCOT, Mumbai. Commercial ginning studies on rollers were performed at M/S Vijay Cotton Ginning and Pressing Mill, Bailhongal.

To study the heavy metal as total chromium mg/kg (ppm) in cotton lint samples, seed samples, seed-cotton samples, CCLC roller samples, CCLC roller samples collected during grooving operation, soil samples from the region of investigation is made, root of the plant for bio-availability, fibre, yarn, fabric samples, textile effluent samples, the standard American Public Health Association (APHA) method was followed for chromium (as total and hexavalent) analysis using AAS. Respirable and suspended particulate matter quantity in gin house air were monitored using High Volume Air Sampler (HVAS) with cascade impactor with appropriate glass fibre filters. (Rao, M.N. and Rao, H.V.N. , *1989)***.**The quantity of pollutants are collected in HVAS as 8 hours basis and analyzed for chromium. The worker dose and exposure time were found using the personal sampler. Cotton technological parameters were tested using High Volume Instrument (HVI) and Scanning Electron Microscope (SEM) for chrome roller ginned lint and eco-friendly roller ginned lint. Some of the chrome tanneries at Chennai, Kanpur and Calcutta were visited for an appraisal of chromium pollution problems. A health study is conducted by the author at Guntur, Bailhongal, Sendwa, Surendranagar, India, Tanzania and other countries, where maximum number of ginning factories are situated to survey the health effects and occupational health hazards. Since ginning being a seasonal activity over a few months of the year, it was not possible to study the health aspects. Further there were no medical/ health records available/provided.

To design and develop eco-friendly RCF rollers , the ginning investigations were carried out at Central Institute for Research on Cotton Technology (CIRCOT), Mumbai. The laboratory rollers for Gin Roller Experimentation Device (GRED) were designed and fabricated at Calcutta at a local manufacturing firm. Prototype rollers were also fabricated and developed .

4 Results and Discussions

An experiment is conducted to find out the wearing and compactness rate of CCLC rollers used by roller ginning industries for a season lasting three months. At the start of season the diameter of rollers are 180 mm. At the end of season the roller dimensions are noted at left, middle and right positions for all the roller gins in the factory, that is 18 ginning machines. The results are presented (Table-1). Apart from the wear and tear rate, the table expresses the quantity of pollutants generating during the operation, viz. chromium, leather powder, cotton dust and chrome specific dust. It is found that the wearing rate is 0.033mm / hour and the percentage material removed per roller 43.8%. The final diameter at the end of

study is nearing 140mm. The compaction rate is 0.050 mm/hour. Initial diameter of the rollers = 180 mm. Chromium roller compactness rate is –0.010 to –0.050 mm, i.e. –10 to –50 μm per hour. Wearing rate is 0.033mm / hour and the percentage material removed per roller is 43.8%.

Characterization and environmental assessment studies of chromium pollution existing with the CCLC rollers were conducted. The CCLC roller contains 18 077 mg/kg (ppm) to 30 780 mg/kg (ppm) as total chromium (3 to 4% as total chromium). This included trivalent and hexavalent chromium. During the ginning operation, lint cotton adsorbs chromium particles which contains 143 mg/kg (ppm) to 1994 mg/kg (ppm). The CCLC roller is grooved at the start of each shift and filing or turning of the roller for leveling is done to get uniform diameter at start of each season. At that time, the wearing of roller is more and presence of chromium to the extent of 1994 mg/kg (ppm) with lint. The total weight of chromium removed during a cotton season of 16 hours per day is 450 to 600 grams per gin roller gin. The chrome specific dust from one ginning machine enters in to environment and being adsorbed in lint stage having the level of 143 ppm. The environmental standard for chromium in spun yarn is 2 ppm and Cr (III) for baby clothing and fabric is 0.1 ppm and nil for Cr (VI). The traces found contain hexavalent chromium being adsorbed from contaminated lint, yarn to fabrics and subsequently cannot be removed in fabrics. There is evidence that the toxic effects are produced on humans due to Cr (III) and Cr (VI) of its carcinogenecity and corrosiveness. The analysis show that traces of Cr (VI) are found in even analar grade trivalent chromium compounds and complications do arise due to the reducibility nature of these traces that affect the organic tissues of the body. This regenerating effects occur rapidly and dependent of the worker dose and exposure time.

Chromium compounds like dichromate, sodium chromate and sulphate of *30% to 60% basicity* are used in the tanning industries. The impure chromates have hexavalent form of chromium salts mixed with chromium sulfate for making semi-finished leather. The locally made indigenous manufacturers in Kanpur, Ahmedabad, Chrompet and Chennai have used this for making ginning rollers. The chromium percent contained in leather was approximately 3 to 4 by weight basis. Table-8 depicts that about 66% of the total chromium compounds applied during tanning process were absorbed in leather and remaining was discharged to effluent .

5. Eco-friendly Chrome Less Roller for Roller Gins

In conventional ginning process, CCLC rollers emits tremendous chromium in ginning environment due to constant dust-producing, grinding action which contaminates the cotton and its products. This also causes air pollution in the mill environment. An exhaustive study is needed for the development of eco-friendly chrome less roller, which can be an alternative to the existing CCLC rollers.

An exhaustive material studies are done for the suitable material's selection of the gin rollers which are made of Walrus animal skin, Spider tuck packing, coir-board, rubber packing, metal cylinder, rubber roll, fabric and rubber packing, leather, cotton, rubber and cork, plastics and fluorinated ethylene propylene. The peculiar gripping action or adherence of the cotton fibres to the roller surface is considered while designing the rollers. The leather surfaces possess *interfibrillary* action, which enables to adhere the fibre on the surface. This particular property is studied extensively for the different materials and combination of different materials so as to design and fabricate laboratory gin chrome less rollers for gin roller experimentation device (GRED) and prototype eco-friendly chrome less rollers for existing DR gins. One of the associated objectives of laboratory studies are to define the physical properties of a roller covering material which contributes to its energy consumption, ginning rate potential, eco-friendly parameters, cotton technological parameters, mechanical engineering analysis, wear resistance properties, heat proof capacity and to search better roller covering materials.

6.Rubber Processing RCF

Specifications and rubber compounding were followed as per standards from Rubber Board and IS- 3400 (Rubber Board, 1990). The rubber processing technology for making RCF roller was studied at Rubber Technology Centre, at Indian Institute of Technology, Kharagpur and Rubber Board, Kottayam. The following rubber compound materials were selected in fabricating the RCF roller.

6.1 Materials for rubber Compounding (IS-3400)

Natural rubber = 100 Unit
Zinc oxide = 10 Unit
Stearic acid = 2 Unit
Accelerator = 1 Unit
Anti-oxidant (non-staining agent) = 1 Unit
Processing oil 10 Unit
White filler = 40 Unit
Titanium dioxide = 10 Unit
Sulphur = 2.5 Unit
Resin = 20 Unit

6.2 Rubber compounding (Rubber Board)

Natural Rubber = 100 unit
ZnO = 5.0 unit
Stearic Acid = 2.0 unit
S.P (Procing oil) = 1.0 unit
Silica (ppt) = 25.0 unit
Whiting = 20.0 unit
Clay = 50.0 unit
Al. Silicate = 25.0 unit
Wooden resin = 5.0 unit
TiO_2 = 5.0 unit
CBS (accelerator) = 1.0 unit
Sulphur = 2.5 unit

6.3 Process description

Step-I: Machinery and relevant process

Mixing Mill Rubber-mixing compounding
Lathe For making wooden core and for cutting extruded product
Calendar Cotton fabric rubberizing
Covering on roller 9.07 kg for steaming on the calendar
Wrapping Processed in the designed mould Vulcanization of rubber-canvas in close calendar; steam from Boiler at 155°C for 1 hour Unwrapping from the designed mould
Turning on lathe

Step-II: Fabrication

Bore size : 50 mm X 50 mm square/50 mm E/E Hex
Outside diameter : 180 mm
Length : 1020 mm

Rubber having two layers cotton fabric was used up to 140 mm for rubber reinforcement. Later, 11 layers of cotton fabric and rubber were used from 140 mm to 180 mm diameter.

The fabrication of roller was done in prepared mould form and sleeve as per the drawing. After preparation of mould sleeve, the washers of 18 mm thick were cut and supplied on piece rate or weight rate system. Giving less reinforcement of cotton fabrics in the surface minimized the cost of the roller. Plain circular winding with rubber compounding was used to cover over the core shaft.

7 Conclusions

The CCLC rollers used in ginning industries get powdered during ginning operation and enter the environment as chrome specific dust. It was observed that the chrome specific dust contaminates cotton and its products. The chromium contamination levels for cotton and its products were abnormal for all the samples except that the cotton samples obtained from RCF roller gin rollers *i.e.*, eco-friendly ginning industries. As per the environmental standards (MOEF Notification No.157, 1996), chromium content in cotton and its products not to be more than 0.1 ppm. The CCLC roller coverings contained 18 077 to 30 783 mg/kg, (ppm) as total chromium. When the seed-cotton is ginned, the ginned lint cotton gets contaminated to the extent of 143 to 1990 ppm as total chromium. Due to persistent rubbing of CCLC rollers over stationary knives and adsorption property, chromium from CSD as well as pericarp particles left out after ginning process are carried, such that spun yarns get contaminated to the tune of 17 to 250 ppm as total chromium against the safe limit of 0.1 ppm. The CSD contains 4232 $\mu g/m^3$ including RSPM and SPM concentration and 1994

mg/kg (ppm) as total chromium. The chromium uptake from the soil (bio-availability) is 3 ppm. These levels in the case of chrome rollers and CSD are 15 382 and 21 times more that the maximum permissible level as 2 ppm and 200 $\mu g/m^3$ and in the case of lint is more than 71 times of the accepted level, 2 mg/kg (ppm). Worker dose and exposure chromium level on 8 hour basis are 35 times more than the standards of ACHIH TLV (American Conference on Governmental Industrial Hygienists –Thresh Hold Limit Valve) and US OSHA (United States Occupational Safety and Health Adminstration).

The manufacturing technology, design engineering features and assembly drawings show that the conventional fabric and rubber roller gin covering material is selected with the following characteristics, namely,

1. Hardness of 90 (type DO durometer) ,
2. 9 to 10 layers of fabrics 20 mm length,
3. Thickness of fabrics 1.2 mm,
4. The rubber compounding is resilient and
5. 0.76 mm of fibre bristles protrude beyond the rubber surface is maintained in spite of wear.

On the basis of the design and development of various rollers with subsequent performance evaluation studies, chrome-free RCF roller has been demonstrated with reference to techno-commercial and eco-friendliness in ginning industries. The newly developed RCF rollers are successful and effective in functioning and in ginning out the seed-cotton.

Cost economics study reveals that eco-friendly RCF roller ginnery sounds better in all aspects with reference to environmental, cotton technological and techno-commercial aspects.

7.1 Comparative Economics

Comparative economics have been worked out for the chromeless RCF roller ginneries and CCLC rollers ginneries; that is for both the 'System before and after modifications' and for commercialization to the ginning industries.

Table 1 Present Status Comparative Economics as on Date

S. N.	CCLC rollers for DR gins (System Before Modification)	Eco-friendly, chrome-free RCF roller for DR gins (System After Modification)	Saving with RCF roller
1.	Initial cost Rs.7/- to 20/- per washer/ disk. The washers can be used for 2 to 3 months in a cotton season. About two times, new washers are to be replaced in an year. Maintenance cost is ten times more than RCF roller gins, because of roller grooving, gin-settings and pressure adjustments are to be done at frequent intervals. Lower productivity. Cr contamination and pollution problems are there in major cotton growing areas in India, Tanzania, Africa and Egypt.	*Initial cost is Rs. 88/- per washer.* Though the initial cost of the RCF roller is 11 times more than the life of CCLC roller, the high price is compensated, as it is durable up to seven years. There is zero maintenance.Considering the maintenance and washer replacement cost, the washer cost worked out to be Rs.18/- per washer. No grooving is required except in initial maintenance. High productivity. Cleaner production. No waste in product. Chromium contamination and pollution problems are not there.	Though the initial cost is more, washer replacement and maintenance cost is 8 times less than the CCLC washer.
2.	Initial total cost is Rs.1,500/-per roller	Initial total cost is Rs. 1350/- per roller	Rs. 150/-
3.	Washer replacement cost for a ginning industry having 12 DR gins is Rs. 72,000/- per cotton season.	Washer replacement of a ginning industry having 12 DR gins is Rs. 62,800/- per cotton season	Rs. 9,200/-
4.	Medical charges for treating the workers is abnormal	Charges for treating the workers is very less in respect of chromium pollution problem and benefits increase manifold	Safe environment
5.	Labour output per hour is 1.2 standard performances rating	Labour output per hour is 2.4standard performances rating which is twice than CCLC ginning industries because of cleaner environment	Safe environment
6.	Gin output is 1.25 times less than the RCF ginning industries.	Gin output is of about 1.25 times more than the CCLC rollers because of the developed roller made up of RCF and has got a surface finish conducive to high ginning efficiency.	1.25 times
8.	Washer is consumable.	Washer is not consumable.	7 years life
9.	Unsafe chromium contamination and pollution.	Safe environment. No chromium pollution in the environment.	Eco-friendly technology

Further, the following recommendations are suggested;

1. Most of the cotton ginning operations are done using roller gins in India, Africa, Tanzania and Egypt. Out of the lint obtained from these CCLC roller ginneries in this countries, it is quite important to appreciate the fact that the lint so produces is contaminated with chromium powder produces deleterious effect on the people working in the vicinity. Yarn and seed obtained is also contaminated with chromium. Toxic effects are produced by prolonged contact with airborne or solid or liquid chromium contamination and pollution even in small quantities. Hence, it is imperative that a policy decision be taken to replace the presently used CCLC rollers with eco-friendly rollers or vegetable tanned leather rollers.
2. Industry, Government and Regulator should come forward to subsidize this venture in view of its demonstrated and proven techno-commercial feasibility in connection with eco-friendliness.
3. Immediate action must be required by the concerned Government regulatory agencies for transfer of eco-friendly technology to the ginning industries and thus save environment.
4. Comprehensive studies on Air Pollution particularly in the ginning environment and its correlation with socio-economic and health studies need to be carried out.

Acknowledgements:
The author is thankful to All India Council for Technical Education, New Delhi for the award of Emeritus fellowship to the first author during 2005 to 2008.

References:

1. Bandyopadhyay, K. and Gangopadhyay, A. and Son, N.N. (*2000).* "Adsorption Study on Fly Ash as a Waste Resource for the Removal of Chromium." *World Congress on Sustainable Development Proceedings,* Vol. I, pp. 532-539,

2. Gillum, N., and Marvis, *(1964).* " Properties of Roller Covering Materials", United States Department of Agriculture (USDA*), Technical Bulletin No.1490, Washington: pp.1-45, 1994.*

3. *Reference No. 157,* MOEF Notification No.157, *dated 4.5.1996.*
4. Shete, D.G. and Sundaram ,V. (*1993).* "Some Practical Hints for Better Ginning of Cotton
5. Sujana, M.G. and Rao, S.B. (*1997).* "Unsafe Chromium." Science Reporter, pp.27-30, *Sep.1997.*
6. Townsend J.S. Walton T.C. and Martin J. (1940) Roller Gin Construction, Operation and Maintenance, U.S. Department of Agriculture, Washington, USA.