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Mathematical Model Describing Effect of S.Cerella on Paddy in the Environmental Ecosystem

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Abstract

In this paper we will establish a mathematical model with the help of second order differential equations by assuming that the rate of change of percentage germination loss with respect to grain infestation is proportional to germination loss. We have selected entomological data for our problem to be in the paper. The model is useful for better management of storage of grains and it will reduce the storage losses of grains under the consideration of various parameters like moisture, humidity etc.

Keywords: Germination loss , Infestation loss , Grains , Storage system etc.

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1. Introduction: In agriculture departments of various universities of World , where agricultural researches are going on, plentiful statistics are available to provide a basis for various analytical study. As a matter of fact, they are not of as much use as it ought to be because they are fragmentary and inconclusive. For this model we have gone through the research work of $[1]$ Kapoor,J.N, $[2]$ Pandey.V, $[3]$ Prkash .A , $[4]$. Singh R.A and Rizvi. S.M , $[5]$ Singh V , $[6]$ **A**shamo M. O et al. Through mathematical models we give them systematic order to gain better insight into the problem for data has been collected, so that data may prove more useful for agricultural production. To have a clear and complete picture and the results of various problems consideration data are required for the formation of mathematical models. The storage condition which gives the validity and vigour of the seeds and various type of losses as a result of physiological and biochemical changes, differs considerably under the different storage system. In stores, grains absorb moisture because of humidity and get infected, resulting into development of insect population. Besides, these are perspiration or metabolic changes, depletion of foods reserves such as carbohydrates, proteins and oil, genetic changes and changes in membrane permeability. All these factors cause huge losses during storage. Therefore, it seems essential to study the effects of these factors and establish their relationship through modelling for better management and forecasting.

Due to high humidity harvested and processed paddy retains high moisture content, which predisposes grains for considerable storage losses every year. Paddy in storage is damaged by a dozen insects but only a few viz. angoumsis grain moth, Sitotroga Cerealella oliv etc are most harmful insects to damage grains. Pest status of an insect in rice storage period and local climatic conditions. A biotic environment like the grain moisture, humidity temperature, light and type of storage structure mentioned earlier and the storage losses due to insects. Losses may be quantitative and qualitative, i.e. reduced germination and contamination with mycotoxins.We have discussed some factors affecting the storage ecosystem, like atmosphere humidity and grain moisture content, temperature, light, season food etc.

We will establish a Mathematical model with the help of second order differential equations by assuming that the rate of change of percentage germination loss with respect to grain infestation is proportional to germination loss.

2. Formulation of the model

We conducted an experiments at Achrya Narendra Dev Agriculture University,crop research station, Faizabad U.P. we have selected twenty five grams of seed ,each of 10 selected varieties ,comprising of 5 grain types were kept in 100*25 mm size preterlised glass specimen tubes, were placed inside the desiciotor with some adult moth and performed the whole experiment under different environment conditions for different periods. We have extracted statistics from the experiments to develop mathematical models by considering two varieties viz. percentage grain infestation and percentage loss in germination.

Losses in grains weight and germination of rice varieties infested by S.Cearelella of 3, 6, and 9 months of duration.

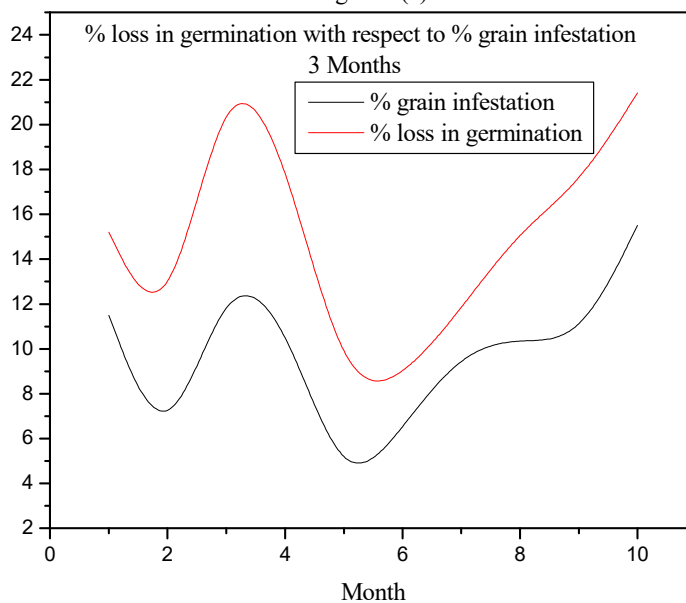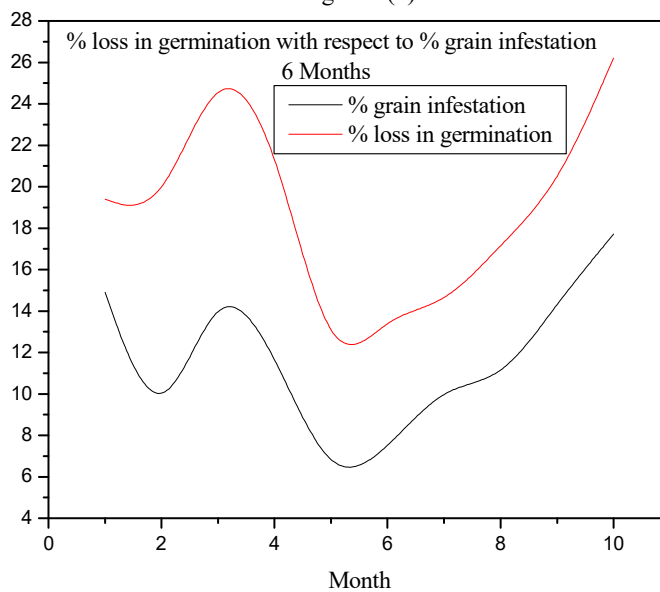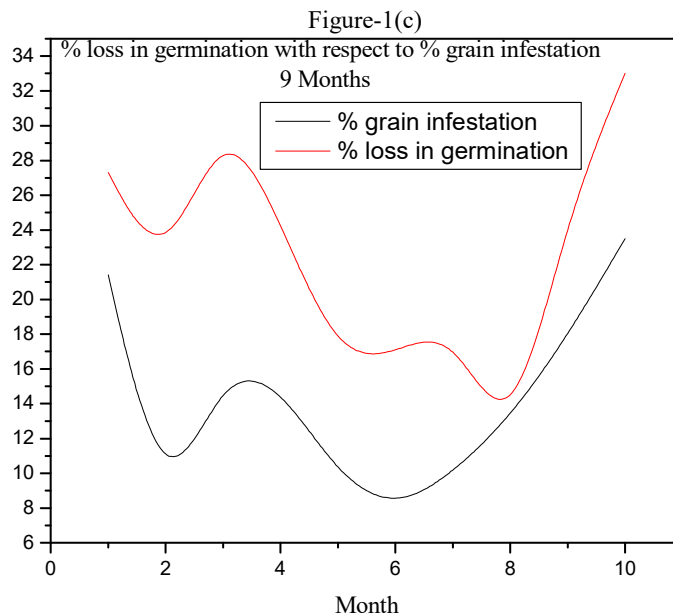| % Grain infestation			% Loss in germination		
3 months	6 months	9 months	3 months	6 months	9 months
11.5	14.9	21.4	15.2	19.4	27.3
4.6	7.3	7.3	9.9	18.5	21.2
13.7	16.1	16.1	23.3	26.5	31.0
11.5	12.1	15.1	18.9	22.7	24.5
3.3	5.4	9.8	8.0	10.5	16.5
6.5	7.3	7.9	8.6	13.9	16.9
9.9	10.5	10.0	11.8	14.2	18.5
10.5	10.5	13.2	15.3	17.2	10.9
10.2	14.4	17.9	17.3	19.9	25.0
15.5	17.7	23.5	21.4	26.2	33.0

Figure-1(a)

Figure-1(b)

Figure-1(c)

From figures, it evinces that percentage loss in germination value is behaving in oscillatory manner with respect to (kernel) percentage grain infestation. Therefore, it is postulated that percentage germination loss with respect to percentage grain infestation obeys a law where solution shows the oscillatory nature. Before trying any law to mould this situation we first idealise the experimental data to the extent that the idealised data is included most of the original data and some averaged data. The idealisation is required for the reason as follows:

To curve in figure is idealised to give a curve of frequency which shows the nature of oscillation. To obtain observation Percentage loss in germination X_i are averaged at averaged kernel (grain infestation) for further use.

Average experimental data		Idealised average data	
Kernel infestation	Germination percent loss	Kernel infestation	Germination percent loss
75.9	20.6	16	21
7.4	22.0	7	10
17.2	26.9	17	27
18.1	24.1	19	28
6.1	22.0	6	12
7.2	11.6	7	17
10.1	14.8	10	15
11.4	14.4	11	10
14.1	20.7	14	21
18.9	26.8	19	27

Also we have omitted one data of germination losses X_i at grain infestation Y_i. Simply because they are not behaving according to the general trends of the other data, may be due to some other variables presented at the time of recording the data but they are not present here. Other observations of the table are as the same five in table 2. According to the follow up of the idealised data and corresponding curve.

It is postulated that the rate of percentage germination loss 'Z' with respect to grain infestation 'I' is proportional to the Z i.e.

$$\frac{d^2Z}{dI^2} \, \alpha \, Z$$

Or, $$\frac{d^2Z}{dI^2} = -\omega^2 Z \quad \text{---------(1)}$$

Where ω^2 is constant of proportionality.

2.1 Discussion and solution:
Solution of equation (1) is given by

$$Z = C_1 \cos \omega I + C_2 \sin \omega I \text{----------(2)}$$

Where C_1 and C_2 are arbitrary constant.

An equivalent expression for the solution of equation (1) is

$$Z = A \sin(\omega I + \phi) \text{----------------(3)}$$

Where $\sin(\omega I + \phi) = \sin \omega I \cos \phi + \cos \omega I \sin \phi$ -----------(4)

Using equation (4) in equation (3) we arrive at

$$Z = A \sin \omega I \cos \phi + A \cos \omega I \sin \phi \text{--------------(5)}$$

In view of equations (3) and (5) we get,

$$C_1 = A \sin \phi \text{----------(6)}$$

$$C_2 = A \cos \phi \text{---------(7)}$$

Which evidently provide us

$$A^2 = C_1^2 + C_2^2 \quad \text{and} \quad \phi = \tan^{-1}(C_1 / C_2)$$

Where A is called amplitude of oscillation and the oscillation is $(\omega I + \phi)$ Phase angle is ϕ

If we start from maximum point i.e. $\phi = \dfrac{\pi}{2}$ in equation (5) reduces to

$$Z = A \cos \omega I \text{-------(8)}$$

Where w is the circular frequency and equation (6) and (7) reduces to

$$C_1 = A, C_2 = 0$$

ω is also expressed in terms of period as

$$\omega = \frac{2\pi}{T} \text{----------(9)}$$

Where T is the period of oscillation or distance between two points.

Using equation (8) and (9), we get,

$$p = A \cos\left(\frac{2\pi}{T}\right) l \text{-------------(10)}$$

$$\text{At} \quad \phi = \frac{\pi}{2}$$

We claim that equation (10) in the model representing the data given in table. To justify the claim we proceed to test the model.

Equation (10) is expected to generate data represented by fig (2). It is evident that equation (10) represents a wave equation where the displacement curve is represented with respect to a line of symmetry which we term as a "line of best fit" of the data table, so fitting a line $y = mx + c$, to the data we obtain the equation.

$$y = 0.90x + 11.5 \text{ -------}(11)$$

the inclination of line is 0.90 which gives remarkable effect i.e. germination value of grains is directly depend upon percent grain infestation.

Let, $u = x - 10$, $v = y - 20$

x	y	u	v	uv	u^2
16	21	+6	1	-6	36
7	10	-3	-10	30	9
17	27	7	7	49	49
19	28	9	8	72	81
6	12	-4	-8	32	16
7	17	-3	-3	9	9
10	15	0	-5	0	0
11	10	1	-10	-10	1
14	21	3	1	3	9
		$\sum u = 16$	$\sum v = 19$	$\sum uv = 198$	$\sum u^2 = 209$

$$x = 10 \; + \; \left(16/9\right) \; = \; 11.7$$
$$y = 20 \; + \; \left(19/9\right) \; = \; 22.1$$

$$b_{yx} = \frac{\left(9 \times 198\right) - \left(16 \times 19\right)}{\left(9 \times 209\right) - \left(16\right)^2}$$

$$b_{yx} = 0.90$$

Hence regression line is given by

$$y \; - \; 22.1 = 0.90\left(x \; - \; 11.7\right)$$
$$y \; = \; 0.9x \; + \; 11.4 \qquad --------(12)$$

3. Conclusion

We conclude from this model that Infestation by S.Cerealella inflected considerable damage to impact significant varieties in germination between different storage periods. As insect infestation increased progressively with the storage period, germination decreased following more or less similar trend. Insect infestation is dependent upon the number of insect present in the store. Also increase in population of insect depends upon the environmental factors i.e. environmental ecosystem. This mathematical model lays emphasis on the role insect infestation during storage of grains, in reducing germination which proves its efficiency in itself.

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Preparation of Indigenous Copper Oxide Nanoparticles for Desulfurization of Natural Gas

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Abstract

Nanotechnology has attained significant concern in the field of Environmental Protection, Health Risk Energy, Material Science, Biotechnology, Information Technology, Pharmaceuticals, Tissue Engineering, Cosmetics, Food and Agriculture, and others. In this research the preparation of indigenous copper oxide Nanoparticles (Cu_2O NPs) were prepared by the bottom up approach in the presence of Sodium do Decyl Sulfate (SDS). Material properties of Copper oxide NPs such as Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD) and Fourier Transforms Infrared (FTIR) spectroscopy were also studied. The SEM demonstrated the surface of indigenous Copper Oxide NPs was non-agglomerated powders with irregular ball resembling particles. The X-ray Diffraction (XRD) analysis explained that the Cu_2O NPs were highly crystalline in nature with average size was found to be 3.5 nm ranging from 2 to 5 nm were recorded by the help of scherrer formula. The Fourier transforms infrared (FTIR) spectroscopy described the carbonyl group are responsible for formation of stable indigenous Cu_2O NPs. These stable Indigenous cuprous oxide nanoparticles would be applied for the desulfurization of natural Gas separation purpose.

Keywords: Indigenous, Copper oxide nanoparticles (Cu_2O NPs), chemical reduction, SDS, morphology, desulfurization and natural gas.

1. Introduction

Nanotechnology is integrative field that covers diversified knowledge about the preparation, design and engineering of Nano-sized equipments and materials [2]. Ancient Historic evolution of nanotechnology is defined by Daniel and Astruc . The begging of 21st century rapid progress in the field of Nanotechnology has initiated with establishment of National Nanotechnology Initiative [3]. It is an engineering of manufacturing very small Nano-sized l particles, materials and devices [4]. By applying the principles of Nanotechnology, research have developed various indigenous materials at Nano scale having at least one side < 100 nm [5]. Nanotechnology is used to improving the various other fields like medicine, chemistry, information technology, many engineering technologies and others to develop the novel Nano-structured indigenous material [6]. Numerous synthesis methods are developed to enhancing the various properties of nanoparticles with low cost [7]. Nanoparticles are generally classified into carbon, organic and Inorganic based, Furthermore inorganic are classified as metal based, metal oxide based. Nearly all metals can be converted in to metal nanoparticles, however metal oxides nanoparticles possess high reactivity and high efficiency [8-10].

Researchers have developed NPs of various metal oxides like MgO, Cu_2O, CuO, ZnO , Fe_3O_4, CaO, TiO_2, ZrO_2, CeO, NiO, SnO_2, Al_2O_3, CdO_3 and Co_3O_4 through different available techniques [11-14]. With the advancement in the field of nanotechnology, NPs are developed for the removal of impurities from the fuels. NPs of metal oxide has been tested for removal of Sulfur and sulfur compounds from gas due to high surface area , high reactivity i.e , TiO_2 has been used for removal of SO_2 from gas, ZnO and Iron oxide used for removal of hydrogen sulfide and other sulfur compounds from gas [14-16].

In this study cuprous oxide nanoparticles were prepared by chemical reduction method and Characterization was done by Scan Electron Microscopy (SEM), Fourier Transforms Infrared and spectroscopy (FTIR). These indigenous cuprous oxide nanoparticles will be used for the Desulfurization of Natural Gas using Indigenous cuprous oxide nanoparticles.

2. Experimental Setup:

2.1. Materials and reagents

All chemicals used were of analytical grade and used without further purification by employing pure Milli-Q water as the preparation medium. Copper Sulfate ($CuO_4S.5H_2O$), Sodium dodecyl Sulfate ($C_{12}H_{25}NaO_4S$), Ascorbic acid ($C_6H_8O_6$) and Sodium hydroxide (NaOH) were purchased from E.Merck.

2.2. Instrumentation Setup

The Ultra-visible spectroscopy model (Lambda 356 of Perkin-Elmer) initially used for investigation of

indigenous Cu_2O NPs by showing Surface Plasmon Resonance (SPR) band within the UV-visible range of 200-800 nm [17]. The X-ray Diffraction (D-8 Bruker) one of the best non-destructive techniques used for the phase purity and crystalline patterns confirmation of indigenous Cu_2O NPs and Scanning Electron Microscopy (model JSM-6380LV) used for the morphological characterization of Cu_2O NPs [18, 19]. The surface interaction was identified by Fourier transforms infrared (FTIR) spectroscopy (Nicolet 5700 of Thermo).

2.3 Preparation procedure of indigenous Cu_2O NPs

Aqueous solution of Sodium dodecyl suphate was prepared by dissolving 1.13g of Sodium dodecyl sulfate in distilled water with constant stirring for 15 min. Pre-prepared of aqueous solution of 0.1M Copper Sulfate was added into the SDS solution under uniform stirring and then aqueous solution of 0.1M Ascorbic Acid was added instantly. 1 M Sodium Hydroxide solution was used to attain the 9 pH value of the mixture. Prepared mixture was placed at 90^0C for 2 hours. Solution was left over 1 night and then washed the distilled water and ethanol for removing inorganic and organic impurities and dried at room temperature. Finally we obtained greenish powder product and storage it for characterization purpose.

3. Results and Discussions

3.1. Scanning Electron Microscopy (SEM) Study

The surface characterization of indigenous Cu_2O NPs was done by Scanning Electron Microscopy (SEM).   The formation of non-agglomerated powders with irregular ball like particles were formed as shown in Figure 1(a, b)and also with showed that the aggregated mostly round shape structure of Cu_2O NPs.
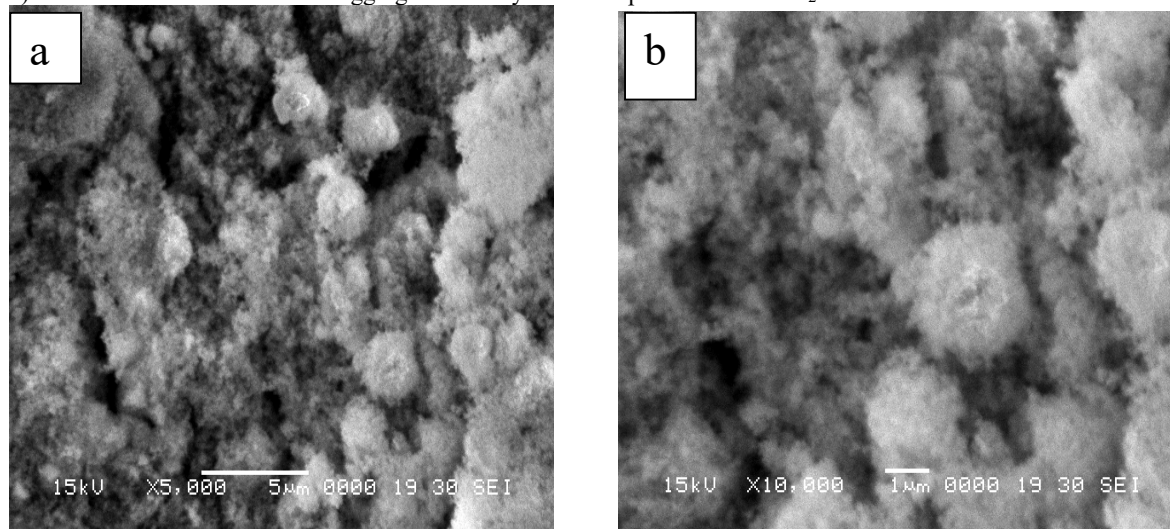

Figure 1: SEM images (a and b) of indigenous cuprous oxide nanoparticles

3.2. X-ray diffractometry (XRD) Study

The X-ray diffraction (XRD) analysis used for the phase purity and crystalline structure of indigenous Cu_2O NPs, as represented in Figure 2. The XRD spectrum clearly represents five major peaks with miller indexed peak (110), (111), (200), (220) and (311) of Cu_2O. On the contrary, there are no extra peaks of copper and CuO were observed [20]. The scherrer equation was used for determining the average particles size of ingenious Cu_2O NPs was found to be 3.5 nm with particles range from 2 to 5 nm.
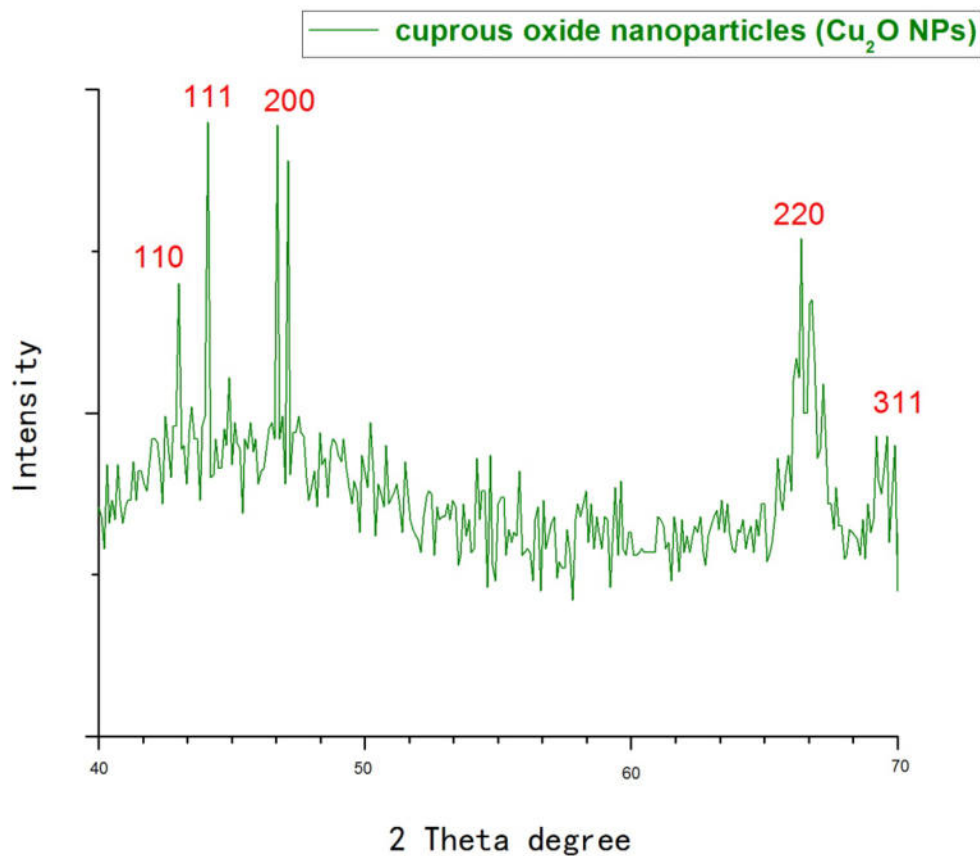
Figure 2: XRD Spectrum of indigenous Cu_2O NPs

3.3. Infrared spectroscopy (FTIR) study

FTIR spectrum of indigenous copper oxide nanoparticles showed various bands that depend upon the vibrational modes[21]. Figure 3 (a, b and c) represent FTIR spectrum of Cu_2O NPs, SDS and ascorbic acid. Figure 3a showed that spectrum of Cu_2O NPs can be interpreted bored and highest intensity of amino group stretching at 3322 cm^{-1} and bending at 1547 cm^{-1} as compares to SDS and ascorbic acid in Figure (b and c). The band observed at 1753 cm^{-1} confirms the presence of carbonyl group (-C=O) in ascorbic acid clearly disappears in Figure (a). This is the clearly evidence of formation of indigenous Cu_2O NPs.
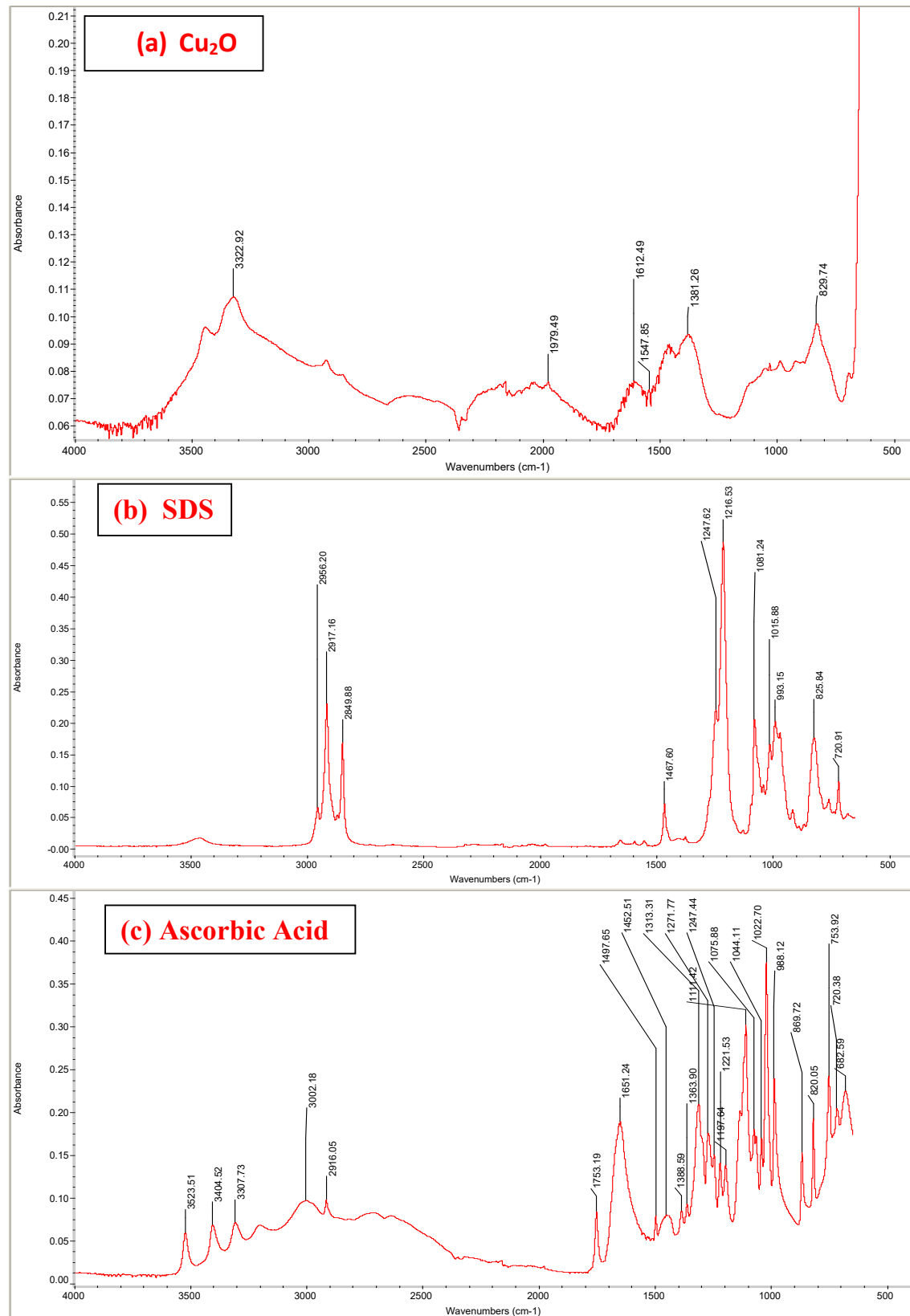
Figure 3: FTIR spectrum of (a) Cu_2O NPs and (b) SDS and (c) ascorbic acid

3. Conclusion

The stable, economical and simple indigenous cuprous oxide nanoparticles were formed by the simplest chemical reduction method. These indigenous Cu_2O NPs were successfully characterized by Scanning Electron Microscopy (SEM), X-ray Diffraction (XRD) and Fourier Transforms Infrared spectroscopy (FTIR) spectroscopy and finally that the unique particles size of these Cu_2O NPs was found to be 3.5 nm which ranging from 2 to 5 nm would applicable for the desulfurization of natural Gas separation purpose.

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