CHAPTER - 6
SUMMARY OF FINDINGS AND CONCLUSION

6.1 Introduction 365
6.2 Major Findings of the study 366
6.3 Suggestion for Further Research 385
6.4 Conclusion 386
CHAPTER-VI
SUMMARY OF FINDINGS AND CONCLUSION

6.1 Introduction

This chapter provides the summary of findings, suggestions for further research and conclusion. The major findings of have been categorized into two major headings i.e. findings of Scientometric Analysis and Findings of Social Network Analysis.

The scholarly communications of scientists and authors in journals are purely formal, while this established of collaboration through formal modes are established through various informal modes of communications which has been studied by many researchers still there is scope to uncover the basic factors of leading to collaboration among scientists and authors. The collaboration among developed countries is high compared to developing countries which are witnessed in this study also. The reasons for liking of collaboration of developing countries and institutes towards developed countries has to be identified effectively, many of the previous research imply that this liking is based on the favoritism of international journals toward developed countries, technological richness and most importantly global impact. The collaboration has not evacuated single authorship completely as predicted by great scientist way long in 1990’s , it shows that still there are many researchers and scientist who prefer to work solely on their research and research communications even in digital era.

There is clear evidence that in Biotechnology journals there is power law distribution among authors, which is clearly visible in author collaboration and ego-network analysis. The collaboration in Biotechnology literature has witnessed growth over years, i.e. Biotechnologist has become more and more collaborative over years. The number of articles has also increased in number over years, which is influence of high usage of Information communication technology by Biotechnologist. Many interesting studies conducted over time on faculties, scientists and researchers have shown that journals and journal articles have continued to be valued resources. The collaboration of institute has also witnessed within country and outside the country. The sociographs shows the collaboration ties among authors of Biotechnology journals, there are multiple ties among authors enhancing the proof of power law distribution
among authors. Understanding collaboration among authors is beneficiary to know the influence factor of one author with another author in collaborating scholarly for carrying research more effectively.

6.2 Summary of Major Findings

The Major findings of the study from Scientometric Analysis and Social Network Analysis are given below.

6.2.1 Scientometric Analysis

The Scientometric Analysis of the data revealed following findings of Biotechnology literature:

1. The world output form ten journals in ten years from 2003-2012 is 18623; Journal of Biotechnology has published 5991 (32.16%), Bioscience, Biotechnology and Biochemistry with 4652 (24.97%) articles. Journal of Chemical Technology & Biotechnology with 2091 (11.22%) followed by Current Opinion in Biotechnology with 1567 (8.41%) articles. Journal of Industrial Microbiology & Technology with 1440 (7.73%) articles followed by Biotechnology and Bio-process engineering with 1145 (6.14%) articles. Food Technology & Biotechnology has published 629 (3.37%) articles, followed by Biotechnology Advances with 643 (3.45%) articles. Animal Biotechnology has published 244 (1.31%), articles published in Food Biotechnology is 221 (1.18%)

2. 1.31 percent growth rate is noted from ten journals Biotechnology literature for ten years.

3. 15.13 overall doubling-time has recorded for Biotechnology literature for 2003-2012 years.

4. The two-tailed P value calculated for Biotechnology literature is less than 0.0001 for providing statistical evidence for co-relation of growth of Biotechnology literature with years

5. Out of 18623 results 66.75% is research articles, 3.44% is proceedings of paper, 0.41% is corrections, 1.22% is editorial material, 0.07% is biographical item, 17.48% meeting abstract, 0.03% book chapter, 0.01% is letters.
6. In 2003 citations received for 1225 articles is 760, 2156 citations were received in 2004 for 1212 articles, followed by 5231 citations in the year 2005 for 1892 articles, 9557 citations were received in 2006 for 1579 and 13908 citations were received in 2007 for 1972 articles, followed by 18456 citations in year 2008 for 1723 articles. Out of 189388 citations 22967 were received in year 2009 for 1901 articles and 30286 citations in year 2010 for 3064 articles, followed by 38055 citations in the year 2011 for 2118 articles, lastly 48012 citations were received in the year 2012 for 1937 articles. Highest number of citations were received in year 2010 i.e. 48012 citations and lowest number citations were received in year 2003 i.e. 760.

7. The two-tailed P value calculated Biotechnology literature is 0.0001, this difference is considered to be extremely statistically significant, this proves that there is co-relation of citations over years in Biotechnology literature of ten journals.

8. Out of 18623 publications highest number of articles were published by Japan with 4591(24.65%), second highest articles were published by USA with 1838 (9.86%), China has published 1738 (9.33%), 1536 (8.24%) articles were published by South Korea, Germany has published 931 (4.99%), 773 (4.15%) has published by Italy, followed by 770 (4.13%) articles by India, Spain has published 738 (3.96%) articles, 638 (3.42%)articles has been published by Turkey, England stands ten on the list with 498 (2.67%) articles.

9. Indian research output in Biotechnology journals during 2003-2012, top highest number of articles were published in Journal of Chemical technology and Biotechnology with 201(26.1%), followed by 126 (16.36 %) articles in Journal of Industrial chemical technology and Biotechnology, in Journal of Biotechnology with 115(14.93%), in Biotechnology and Bio-process engineering with 105(13.63%), in Biotechnology Advances with 89 (11.55%), in Food technology and Biotechnology with 64 (8.31%) , seventh highest number articles were published in Food Biotechnology journal with 32 (4.15%). In Animal Biotechnology 20 (2.59%) articles were published, followed by Bio-science, Biotechnology and bio-chemistry journal with 15 (1.94%) of total output, least amount of articles were published in Current Opinion in Biotechnology journal with 3 (0.38%) articles though the journal has highest number of citations and high h-index.
10. Among institutes Kyoto University and University of Tokyo stands first with highest number of articles 312 (1.67%), followed by National Agricultural Research Centre Japan has published 244 (1.31%) third highest articles has been published from Chinese Academy of Sciences 226 (1.21%) followed by Hokkaido University with 192 (1.03%). Tokyo University of Agriculture has published 192 (1.03%) articles, followed by Kyushu University with 161 (0.86%) Council of Scientific Industrial Research -India has published 158 (0.84%) followed by Tohoku University with 158 (0.84%) articles in Biotechnology journals during 2003-2012.

11. Among 18623 Biotechnology articles singled authored articles are 1019 (5.47%), two authored articles are 2431 (13.05%), followed by three authored articles 3448 (18.51%), four authored articles are 3296 (17.69%), five and more than five authored articles are 8429 (45.26%). the total articles published in year 2003 is 1225 (6.57%), 1212 (6.50%) articles in 2004 and 1892 (10.15%) articles were published in year 2005. In 2006 the number of publications is 1579 (8.47%), followed by 1972 (10.58%) in 2007, 1723 (9.25%) articles were published in the year 2008 and 1901 (10.20%) articles were published in 2009. In 2010 the numbers of articles were 3064 (16.45%), followed by 2118 (11.37%) in 2011 and in 2012 articles published were 1937 (10.40%). Highest number of articles was published in the year 2010 with 16.45% and lowest number of articles was published in 2004 with 6.50% out of 18623 articles.

12. In Animal Biotechnology out of 244 articles, singled authored articles are 9 (3.68%), two authored articles are 15 (6.14%), followed by three authored articles 28 (11.47%), four authored articles are 37 (15.16%), five and more than five authored articles are 155 (63.52%). the total articles published in year 2003 is 17 (6.96%), 15 (6.14%) articles in 2004 and 18 (7.37%) articles were published in year 2005. In 2006 the number of publications is 23 (9.42%), followed by 33 (13.52%) in 2007, 27 (11.06%) articles were published in the year 2008 and 28 (11.47%) articles were published in 2009. In 2010 the numbers of articles were 27 (11.06%), followed by 25 (10.24%) in 2011 and in 2012 articles published were 31 (12.70%). Highest number of articles was
published in the year 2007 with 13.52% and lowest number of articles was published in 2004 with 6.14%.

13. In Bioscience, Biotechnology and Biochemistry, singled authored articles are 125 (2.68%), two authored articles are 296 (6.36%), followed by three authored articles 627 (13.47%), four authored articles are 767 (16.48%), five and more than five authored articles are 2837 (60.98%). the total articles published in year 2003 is 459 (9.86%), 425 (9.13%) articles in 2004 and 393 (8.44%) articles were published in year 2005. In 2006 the number of publications is 482 (8.47%), followed by 464 (9.97%) in 2007, 503 (10.81%) articles were published in the year 2008 and 530 (11.39%) articles were published in 2009. In 2010 the numbers of articles were 494 (10.61%), followed by 457 (9.82%) in 2011 and in 2012 articles published were 445 (9.56%). Highest number of articles was published in the year 2009 with 11.39% and lowest number of articles was published in 2005 with 8.44%.

14. In Biotechnology Advances from 2003-2012, in singled authored articles are 80 (12.44%), two authored articles are 138 (21.46%), followed by three authored articles 147 (22.86%), four authored articles are 84 (13.06%), five and more than five authored articles are 194 (30.17%). the total articles published in year 2003 is 38 (5.90%)articles, 15(2.33%)in 2004 and 28 (4.35%) articles were published in year 2005. In 2006 the number of publications is 48 (7.46%), followed by 45 (6.99%) in 2007, 48 (7.46%) articles were published in the year 2008 and 104 (16.17%) articles were published in 2009. In 2010 the numbers of articles were 85 (13.21%), followed by 90 (13.99%) in 2011 and in 2012 articles published were 142 (22.08%). Highest number of articles was published in the year 2012 with 22.08% and lowest number of articles was published in 2004 with 2.33%

15. In Biotechnology Advances out of 643articles, singled authored articles are 80 (12.44%), two authored articles are 138 (21.46%), followed by three authored articles 147 (22.86%), four authored articles are 84 (13.06%), five and more than five authored articles are 194 (30.17%). the total articles published in year 2003 is 38 (5.90%) articles, 15(2.33%)in 2004 and 28 (4.35%) articles were published in year 2005. In 2006 the number of publications is 48 (7.46%), followed by 45 (6.99%) in 2007, 48 (7.46%) articles were published in the year 2008 and 104 (16.17%) articles were published in 2009. In 2010
the numbers of articles were 85 (13.21%), followed by 90 (13.99%) in 2011 and in 2012 articles published were 142 (22.08%). Highest number of articles was published in the year 2012 with 22.08% and lowest number of articles was published in 2004 with 2.33%

16. In Biotechnology and Bio-process Engineering out of 1145 articles, single authored articles are 31 (2.70%), two authored articles are 161 (14.06%), followed by three authored articles 229 (20%), four authored articles are 230 (20.08%), five and more than five authored articles are 494 (43.14%). The total articles published in year 2003 is 63 (5.50%) , 92 (8.03%) articles in 2004 and 92 (8.03%) articles were published in year 2005. In 2006 the number of publications is 95 (8.29%), followed by 107 (9.34%) in 2007, 112 (9.78%) articles were published in the year 2008 and 127 (11.09%) articles were published in 2009. In 2010 the numbers of articles were 144 (12.57%), followed by 156 (13.62%) in 2011 and in 2012 articles published were 157 (13.71%). Highest number of articles was published in the year 2012 with 13.71% and lowest number of articles was published in 2003 with 5.50%

17. In Current Opinion in Biotechnology out of 1567 articles, single authored articles are 266 (16.97%) two authored articles are 493 (31.46%), followed by three authored articles 338 (21.57%), four authored articles are 190 (12.12%), five and more than five authored articles are 280 (17.86%). The total articles published in year 2003 is 103 (6.57%), 97 (6.19%) articles in 2004 and 102 (6.50%) articles were published in year 2005. In 2006 the number of publications is 100 (6.38%), followed by 87 (5.55%) in 2007, 95 (6.06%) articles were published in the year 2008 and 102 (6.50%) articles were published in 2009. In 2010 the numbers of articles were 108 (6.89%), followed by 631 (40.26%) in 2011 and in 2012 articles published were 142 (9.06%). Highest number of articles was published in the year 2011 with 40.26% and lowest number of articles was published in 2008 with 6.06%

18. In Food Biotechnology out of 221 articles, single authored articles are 16 (7.23%), two authored articles are 48 (21.71%), followed by three authored articles 39 (17.64%). Four authored articles are 47 (21.26%) five and more than five authored articles are 71 (32.12%). The total articles published in year 2003 is 15 (6.78%), 17 (7.69%) articles in 2004 and 18 (8.14%) articles were published in year 2005. In 2006 the number of publications is 23 (10.40%),
followed by 21 (9.50%) in 2007, 34 (15.38%) articles were published in the year 2008 and 22 (9.95%) articles were published in 2009. In 2010 the numbers of articles were 26 (11.76%), followed by 22 (9.95%) in 2011 and in 2012 articles published were 23 (10.40%). Highest number of articles was published in the year 2008 with 15.38% and lowest number of articles was published in 2003 with 6.78%

19. In Food Technology and Biotechnology out of 629 articles, single authored articles are 36 (5.72%), two authored articles are 86 (13.67%), followed by three authored articles 138 (21.94%). four authored articles are 124 (19.71%) five and more than five authored articles are 245 (38.95%). the total articles published in year 2003 is 54 (8.58%) , 52 (8.26%) articles in 2004 and 59 (9.38%) articles were published in year 2005. In 2006 the number of publications is 70 (11.12%), followed by 61 (9.69%) in 2007, 65 (10.33%) articles were published in the year 2008 and 65 (10.33%) articles were published in 2009. In 2010 the numbers of articles were 66 (10.49%), followed by 72 (11.44%) in 2011 and in 2012 articles published were 65 (10.33%). Highest number of articles was published in the year 2011 with 11.44% and lowest number of articles was published in 2004 with 8.26%.

20. In Journal of Biotechnology out of 5991 articles, single authored articles are 315 (5.25%), two authored articles are 647 (10.8%), followed by three authored articles 1096 (18.29%). four authored articles are 1090 (18.19%) five and more than five authored articles are 2843 (47.45%). the total articles published in year 2003 is 189 (3.15%), 222 (3.70%) articles in 2004 and 903 (15.07%) articles were published in year 2005. In 2006 the number of publications is 353 (5.89%), followed by 911 (15.20%) in 2007, 412 (6.87%) articles were published in the year 2008 and 486 (8.11%) articles were published in 2009. In 2010 the numbers of articles were 1754 (29.27%), followed by 248 (4.13%) in 2011 and in 2012 articles published were 513 (8.56%). Highest number of articles was published in the year 2010 with 29.27% and lowest number of articles was published in 2003 with 3.15%

21. In Journal of Chemical Technology and Biotechnology out of 2091 articles, single authored articles are 76 (3.63%), two authored articles are 367 (17.55%), followed by three authored articles 516 (24.67%). four authored articles are 456 (21.80%) five and more than five authored articles are 676
(32.32%). the total articles published in year 2003 is 183 (8.75%) , 193 (9.23%) articles in 2004 and 185 (8.84%) articles were published in year 2005. In 2006 the number of publications is256 (12.24%), followed by146 (6.98%) in 2007, 224 (10.71%) articles were published in the year 2008 and 259 (12.38%) articles were published in 2009. In 2010 the numbers of articles were 216 (10.32%), followed by206 (9.85%) in 2011 and in 2012 articles published were 223 (10.66%). Highest number of articles was published in the year 2006 with 12.24%and lowest number of articles was published in 2003 with 8.75%.

22. In Journal of Industrial Microbiology and Biotechnology out of 1440 articles, single authored articles are 65 (4.51%), two authored articles are 180 (12.5%), followed by three authored articles 290 (20.13%). four authored articles are 271 (18.81%) five and more than five authored articles are 634 (44.02%). the total articles published in year 2003 is 104 (7.22%) , 84 (5.83%) articles in 2004 and 94 (6.52%) articles were published in year 2005. In 2006 the number of publications is 129 (8.95%), followed by 97 (6.73%) in 2007, 203 (14.09%) articles were published in the year 2008 and 178 (12.36%) articles were published in 2009. In 2010 the numbers of articles were 144 (10%), followed by 211 (14.65%) in 2011 and in 2012 articles published were 196 (13.61%). Highest number of articles was published in the year 2011 with 14.65%and lowest number of articles was published in 2004 with 14.65%.

23. The total single authored articles during 2003-2012 was 1019 i.e. 5.47 % while multi-authored articles 17604 with 94.52% of total output of 18623 with degree of collaboration 0.94.

24. The two-tailed P value calculated for Biotechnology literature for understanding the growth of multi-authored articles is less than 0.0001, this difference is considered to be extremely statistically significant this proves that there is co-relation of growth of multi authored articles over years.

25. The collaborative index of Biotechnology literature 2003-2012; in Animal Biotechnology total number of articles published during 2003-2012 is 244 with total number of authors 1046, the average author per paper is 4.28 with productive per author 0.23.
26. The Bioscience, Biotechnology and Biochemistry has published 4652 publications with total author count 19851 along with average author per paper 4.26 and productive per author 0.23.

27. Biotechnology advance has 643 total publications by 2103 authors, with average author per paper 3.27 along with productive per author 0.30.

28. In Biotechnology and Bio-process engineering total number of articles published 1145 by 4430 authors with average author per paper 3.86 and 0.25 productive per author.

29. Current Opinion in Biotechnology has published 1567 articles with total 4426 authors along with 2.82 average author per paper and 0.35 productive per author.

30. Food Biotechnology has published 221 articles by 772 total authors, with average author per paper 3.49 and 0.28 productivity per author.

31. In Food Technology & Biotechnology total 629 articles were produced by 2343 authors with average author per paper 3.72 and 0.26 author productivity per paper.

32. Journal of Biotechnology with total 5991 articles by 23472 authors and 3.91 average authors per paper along with 0.25 productivity per author.

33. Journal of Chemical Technology & Biotechnology total 2091 article were produced by 7562 authors with 3.61 average authors per paper and 0.27 productivity per author.

34. Journal of Industrial Microbiology & Technology with total 1440 articles produced by 5549 with average author per paper 3.85 and 0.25 productivity per author during 2003-2012.

35. The prolific authors of Biotechnology literature during 2003-2012, is Puhler A with 62 (0.34%), followed by Takahashi K with 51(0.28%) articles, in third position is Kimura T with 50 (0.27%) articles, at fourth is Nakamura Y with 44 (0.24%) articles, followed Abe K with 42 (0.23%) articles at fifth position. Kimura M stands sixth with 41 (0.22%) articles, followed by Mizuno T with 40 (0.22%) articles at seventh position, Watanabe T 40 (0.22%) articles, Yamauchi S with 40 (0.22%) articles and Yoshida T with 40 (0.22%) articles, followed by Kimura Y with 39 (0.21%) articles at eighth position. Suzuki Y 38 (0.2%) articles are at ninth position along with Yamada K 38 (0.2%) and at
The lotka’s law of author productivity is tested to Biotechnology literature and the number of author’s y, each credited with x number of papers, is inversely proportional to x, which is the output of each individual author is nullified and accepted with results of table-105 and 106.

6.2.2 Social Network Analysis

1. Top four co-authors of Li, N with highest degree of centrality and eigenvector three of authors are i.e. Liu, ZL, Zhao ZH, Dia, YP from China Agriculture University, Beijing, China and Zhao, YZ is from Hebei Agricultural University, China which proves the prominent existence of Homophily in Ego-network of Li, N authorship network therefore i.e. The three of co-authors are from same institute and fourth co-author is from same country and homophily value is 0.611

2. Top four co-authors of Takahashi, K with highest degree of centrality and eigenvector Matsuura, H is from Hokkaido University, Japan, followed by Hattori, M and Yoshida, T is from Tokyo University of Agriculture and Technology, Japan and Nishii, W form RIKEN Genomic Sciences Center, Japan, which proves the prominent existence of Homophily in Ego-network of Takahashi, K authorship network i.e. all the four co-authors are from same country and homophily value is 0.612

3. Top four co-authors of Gasser, RB with highest degree of centrality and eigenvector three of authors are i.e. Campbell, BE is from The University of Melbourne, Australia, Cantacessi, C is from The University of Melbourne, Australia Loukas, A is from James Cook University Australia Sternberg, PW is from California Institute of Technology, USA which proves the prominent existence of Homophily in Ego-network of Gasser, RB authorship network and homophily value is 0.578

4. Top four co-authors of Kim, SW with highest degree of centrality and eigenvector three of authors are i.e. Kang SW is from Dongguk University, Korea Park, C is from Kyung Hee University, Korea Choi, MS is from Gyeongsang National University, Korea Song, YS is from Korea University, Korea which proves that they are from same country i.e. Korea and same and
neighbour institutes which provides evidence of prominent existence of Homophily in Ego-network of Kim, SW authorship network and homophily value is 0.462

5. Top four co-authors of Ghasemi, Y with highest degree of centrality and eigenvector three of authors are i.e. Ghasemian, A, Amini, SR, Ebrahimi, N, Gholami, A all are from Shiraz University of Medical Sciences, Iran, which proves the prominent existence of Homophily in Ego-network of Ghasemi, Y authorship network and homophily value is 0.516

6. Top four co-authors of Levin, RE with highest degree of centrality and eigenvector three of authors are i.e. Cao, J, Abolmaaaty, A, Lu, H and Lu, S is from University of Massachusetts, USA which proves the prominent existence of Homophily in Ego-network of Levin, RE authorship network and homophily value is 0.452

7. Top four co-authors of Pandey, A with highest degree of centrality and eigenvector three of authors are i.e. Soccol, CR, Medeiros, ABP, Spier, MR are from Federal University of Parana, Brazil, Thomaz-Soccol, V is from Positivo University, Brazil which doesn’t prove the prominent existence of Homophily in Ego-network of Pandey, A authorship network and homophily value is 0.524

8. Top four co-authors of Puhler, A with highest degree of centrality and eigenvector three of authors are i.e. Goesmann, A, Kalinowski, J, Szczepanowski, R, and Tauch, A are from Bielefeld University, Germany which proves the prominent existence of Homophily in Ego-network of Puhler, A authorship network and homophily value is 0.552

9. Top four co-authors of Mantzavinos, D with highest degree of centrality and eigenvector three of authors are i.e. Xekoukoulotakis, NP and Kalogerakis, N are from Technical University of Crete, Greece, Coz, A is from University of Cantabria, Spain and Kassinos, D, is from University of Cyprus, Cyprus which proves the prominent existence of Homophily in Ego-network of Mantzavinos, D authorship network and homophily value is 0.752

10. Top four co-authors Chen, J with highest degree of centrality and eigenvector three of authors are i.e. Du, GC, Li, JH, Zhang, DX and Liu, L are from National Tsing Hua University, Taiwan which proves the prominent existence
of Homophily in Ego-network of Mantzavinos, D authorship network and homophily value is 0.652

11. There is significant presence of homophily in ego-network of Biotechnology literature which is witnessed from table-127 to table-146.

12. In Animal Biotechnology, USA has produced highest number of collaborated articles with 83.333 degree of centrality followed by closeness centrality of 83.333 along with 34.601 betweenness centrality and 82.577 eigenvector. China stands second in country–wise collaboration with 41.667 degree of centrality followed by 54.545 closeness centrality along with 73.913 betweenness centrality and eigenvector of 9.70. France stands third on the ranking in collaboration with degree of centrality 20.833, followed by 35.821 closeness centrality along with betweenness centrality 23.37 and eigenvector of 17.346.

13. In Bioscience, Biotechnology and Biochemistry, Japan has highest number of collaborated articles with 83.333 degree of centrality followed by closeness centrality of 88 along with 93.428 betweenness centrality and 90.797 eigenvector. China stands second in country–wise collaboration with 22.728 degree of centrality followed by 53.659 closeness centrality along with 5.788 betweenness centrality and eigenvector of 37.737. USA stands third on the ranking in collaboration with degree of centrality 18.182, followed by 53.012 closeness centrality along with betweenness centrality 5.268 and eigenvector of 35.695.

14. In Biotechnology Advances, USA has produced highest number of collaborated articles with 45.283 degree of centrality followed by closeness centrality of 63.095 along with 19.666 betweenness centrality and 47.178 eigenvector. Australia stands second in country –wise collaboration with 39.623 degree of centrality followed by 60.92 closeness centrality along with 12.132 betweenness centrality and eigenvector of 44.912. India stands third on the ranking in collaboration with degree of centrality 37.736, followed by 58.889 closeness centrality along with betweenness centrality 15.689 and eigenvector of 36.706.

15. In Biotechnology and Bio-process Engineering, Korea has produced highest number of collaborated articles with 37.5 degree of centrality followed by closeness centrality of 15.094 along with 22.52 betweenness centrality and 66.69 eigenvector. Japan stands second in country –wise collaboration with
31.25 degree of centrality followed by 15.023 closeness centrality along with 24.267 betweenness centrality and eigenvector of 55.519. China stands third on the ranking in collaboration with degree of centrality 28.125, followed by 14.612 closeness centrality along with betweenness centrality 21.317 and eigenvector of 51.952.

16. In Current Opinion in Biotechnology, USA has produced highest number of collaborated articles with 62.791 degree of centrality followed by closeness centrality of 29.861 along with 57.216 betweenness centrality and 57.216 eigenvector. Germany stands second in country–wise collaboration with 34.884 degree of centrality followed by 27.215 closeness centrality along with 12.342 betweenness centrality and eigenvector of 52.071. UK stands third on the ranking in collaboration with degree of centrality 27.907 followed by 26.543 closeness centrality along with betweenness centrality 12.555 and eigenvector of 43.656.

17. In Food Biotechnology, USA has produced highest number of collaborated articles with 25 degree of centrality followed by closeness centrality of 9.574 along with 35.079 betweenness centrality and 73.314 eigenvector. Canada stands second in country–wise collaboration with 13.889 degree of centrality followed by 9.091 closeness centrality along with 12.381 betweenness centrality and eigenvector of 39.917. Germany stands third on the ranking in collaboration with degree of centrality 11.111, followed by 9.449 closeness centrality along with betweenness centrality 24.921 and eigenvector of 10.36.

18. In Food Technology and Biotechnology, Croatia has produced highest number of collaborated articles with 29.268 degree of centrality followed by closeness centrality of 16.532 along with 15.807 betweenness centrality and 56.61 eigenvector. Italy stands second in country–wise collaboration with 24.39 degree of centrality followed by 16.599 closeness centrality along with 9.526 betweenness centrality and eigenvector of 55.832. Brazil stands third on the ranking in collaboration with degree of centrality 21.951, followed by 16.599 closeness centrality along with betweenness centrality 13.231 and eigenvector of 14.996.

19. In Journal of Biotechnology, Germany has produced highest number of collaborated articles with 58.571 degree of centrality followed by closeness centrality of 41.176 along with 21.634 betweenness centrality and 48.775.
eigenvector. USA stands second in country-wise collaboration with 52.857 degree of centrality followed by 40.23 closeness centrality along with 23.573 betweenness centrality and eigenvector of 43.035. France stands third on the ranking in collaboration with degree of centrality 38.571, followed by 36.842 closeness centrality along with betweenness centrality 9.305 and eigenvector of 35.611. On the list at twentieth position is Brazil with 14.286 degree of centrality, followed by 33.493 closeness centrality along with 0.341 betweenness centrality and eigenvector 19.275.

20. In Journal of Chemical Technology & Biotechnology journal, UK has produced highest number of collaborated articles with 33.784 degree of centrality followed by closeness centrality of 21.023 along with 19.783 betweenness centrality and 37.108 eigenvector. Spain stands second in country-wise collaboration with 32.432 degree of centrality followed by 21.023 closeness centrality along with 73.913 betweenness centrality and eigenvector of 46.05. USA stands third on the ranking in collaboration with degree of centrality 25.676, followed by 20.613 closeness centrality along with betweenness centrality 9.918 and eigenvector 34.68.

21. In Journal of Industrial Microbiology and Biotechnology, Japan has produced highest number of collaborated articles with 85.714 degree of centrality followed by closeness centrality of 87.5 along with 92.78 betweenness centrality and 90.004 eigenvector. China stands second in country-wise collaboration with 21.429 degree of centrality followed by 53.846 closeness centrality along with 6.127 betweenness centrality and eigenvector of 39.057. USA stands third on the ranking in collaboration with degree of centrality 19.048, followed by 53.165 closeness centrality along with betweenness centrality 5.556 and eigenvector 36.882.

22. In Biotechnology literature USA has produced highest number of collaborated articles with 52.857 degree of centrality followed by closeness centrality of 40.23 along with 23.573 betweenness centrality and 43.035 eigenvector. Japan stands second in country-wise collaboration with 38.571 degree of centrality followed by 36.842 closeness centrality along with 9.305 betweenness centrality and eigenvector of 35.611. China stands third on the ranking in collaboration with degree of centrality 35.714, followed by 37.433 closeness centrality along with betweenness centrality 12.412 and eigenvector 34.05 of on
the list at twentieth position is Mexico with 11.429 degree of centrality, followed by 32.407 closeness centrality along with 0.132 betweenness centrality and eigenvector 13.188.

23. The results from country-wise collaboration network tables from Table-147 to Table-167 prove that there is dominance in collaboration among developed countries compared developing countries.

24. SNA of India’s collaboration in Biotechnology Journals from 2003-2012, reveals that India has highly collaborated with Brazil with 21.87 degree of centrality followed by closeness centrality of 56.14 along with 0.65 betweenness centrality and 42.64 eigenvector. China stands second in country-wise collaboration with 18.75 degree of centrality followed by closeness centrality along with 0.15 betweenness centrality and eigenvector of 40.07. Australia stands third on the ranking in collaboration with degree of centrality 18.75, followed by closeness centrality along with betweenness centrality 0.15 and eigenvector 40.07.

25. In Animal Biotechnology, USDA-ARS (United States Department of Agriculture- Agricultural Research Service of USA) has produced highest number of collaborated articles with 20.27 degree of centrality followed by closeness centrality of 3.124 along with 17.345 betweenness centrality and eigenvector. China Agricultural University- China stands second in Institute-wise collaboration with 13.514 degree of centrality followed by 3.114 closeness centrality along with 12.645 betweenness centrality and eigenvector of 5.656. University of Illinois USA stands third on the ranking in collaboration with degree of centrality 12.162, followed by 3.145 closeness centrality along with betweenness centrality 20.259 and eigenvector 34.762.

26. In Bioscience, Biotechnology and Biochemistry, Kyoto University- Japan has produced highest number of collaborated articles with 24.39 degree of centrality followed by closeness centrality of 9.172 along with 29.415 betweenness centrality and eigenvector. University of Tokyo - Japan stands second in Institute-wise collaboration with 22.764 degree of centrality followed by 9.184 closeness centrality along with 23.243 betweenness centrality and eigenvector of 50.851. RIKEN- Japan stands third on the ranking in collaboration with degree of centrality 15.718, followed by 9.08 closeness centrality along with betweenness centrality 14.72 and eigenvector 35.788.
In Biotechnology Advance, University of Melbourne – Australia has produced highest number of collaborated articles with 23.232 degree of centrality followed by closeness centrality of 1.388 along with 5.614 betweenness centrality and 70.871 eigenvector. Chinese Academy of Sciences-China stands second in Institute –wise collaboration with 10.101 degree of centrality, followed by 1.278 closeness centrality along with 3.072 betweenness centrality and eigenvector of 0. Griffith University- Australia stands third on the ranking in collaboration with degree of centrality 10.101, followed by 1.384 closeness centrality along with betweenness centrality 0.234 and eigenvector -46.791.

In Bioprocess Engineering and Biotechnology, Pusan National University – South Korea has produced highest number of collaborated articles with 20.787 degree of centrality followed by closeness centrality of 1.388 along with 5.614 betweenness centrality and 50.605 eigenvector. Seoul National University-South Korea stands second in Institute –wise collaboration with 20.787 degree of centrality, followed by 6.202 closeness centrality along with 19.391 betweenness centrality and eigenvector of 54.818. Inha University- South Korea stands third on the ranking in collaboration with degree of centrality 18.539, followed by 6.121 closeness centrality along with betweenness centrality 18.153 and eigenvector 29.367.

In Current opinion in Biotechnology, University of California – USA has produced highest number of collaborated articles with 10.156 degree of centrality followed by closeness centrality of 0.97 along with 2.66 betweenness centrality and 84.283 eigenvector. Lawrence Berkeley National Laboratory - USA stands second in Institute –wise collaboration with 6.25 degree of centrality, followed by 0.969 closeness centrality along with 2.075 betweenness centrality and eigenvector of 55.765. University of Maryland - USA stands third on the ranking in collaboration with degree of centrality 5.469, followed by 0.82 closeness centrality along with betweenness centrality 0.234 and eigenvector 0.

In Food Biotechnology, University of Massachusetts has produced highest number of collaborated articles with 18.539 degree of centrality followed by closeness centrality of 6.121 along with 18.153 betweenness centrality and 29.367 eigenvector. University of Massachusetts Amherst stands second in Institute –wise collaboration with 11.798 degree of centrality, followed by

31. In Food technology and Biotechnology, University of Zagreb has produced highest number of collaborated articles with 23.232 degree of centrality followed by closeness centrality of 1.388 along with 5.614 betweenness centrality and -70.871eigenvector. University of Ljubljana stands second in Institute –wise collaboration with 10.101degree of centrality, followed by 1.384 closeness centrality along with 0.234 betweenness centrality and eigenvector of -46.791. Council of Scientific Industrial Research- India stands third on the ranking in collaboration with degree of centrality 10.101 followed by 1.278 closeness centrality along with betweenness centrality 3.072 and eigenvector 0.

32. In Journal of Biotechnology, University of Bielefeld- Germany has produced highest number of collaborated articles with 17.872 degree of centrality followed by closeness centrality of 1.557 along with 29.046 betweenness centrality and 88.06 eigenvector. Chinese Academy of Sciences-China stands second in Institute –wise collaboration with 17.021 degree of centrality, followed by 1.536 closeness centrality along with 19.846 betweenness centrality and eigenvector of 21.954. University of Lund - Sweden stands third on the ranking in collaboration with degree of centrality 11.489, followed by 1.544 closeness centrality along with betweenness centrality 16.609 and eigenvector 6.698.

33. In Journal of Chemical Technology & Biotechnology, Chinese Academy Of Sciences –China has produced highest number of collaborated articles with 26.271 degree of centrality followed by closeness centrality of 1.19 along with 8.33 betweenness centrality and 0 eigenvector. Tianjin University- China stands second in Institute –wise collaboration with 11.017 degree of centrality, followed by 1.041 closeness centrality along with 2.463 betweenness centrality and eigenvector of 0.Zhejiang University – China stands third on the ranking in collaboration with degree of centrality 11.017, followed by 1.041 closeness centrality along with betweenness centrality 2.463 and eigenvector 0.
34. In Journal of Industrial Microbiology and Biotechnology, Chinese Academy Of Sciences – China has produced highest number of collaborated articles with 23.214 degree of centrality followed by closeness centrality of 1.204 along with 6.789 betweenness centrality and 0 eigenvector. United States Department of Agriculture USDA stands second in Institute-wise collaboration with 11.607 degree of centrality, followed by 1.11 closeness centrality along with 2.735 betweenness centrality and eigenvector of 0. Zhejiang University – China stands third on the ranking in collaboration with degree of centrality 11.607, followed by 1.11 closeness centrality along with betweenness centrality 2.719 and eigenvector 0.

35. In Biotechnology literature of ten journals, Kyoto University has produced highest number of collaborated articles with 17.872 degree of centrality followed by closeness centrality of 1.557 along with 19.846 betweenness centrality and 88.06 eigenvector. University of Tokyo stands second in Institute-wise collaboration with 17.021 degree of centrality, followed by 1.536 closeness centrality along with 2.735 betweenness centrality and eigenvector of 21.954. Chinese Academy of Sciences stands third on the ranking in collaboration with degree of centrality 11.489, followed by 1.544 closeness centrality along with betweenness centrality 16.609 and eigenvector 6.698.

36. There is significant presence of Power-law in collaboration of Biotechnologist which is witnessed from tables-168 to tables-189.

37. In Biotechnology literature of ten journals, Alexander Goesmann has produced highest number of collaborated articles with 28.176 degree of centrality followed by closeness centrality of 0.44 along with 8.89 betweenness centrality and -49.813 eigenvector. Alfred Puhler stands second in author collaboration with 28.176 degree of centrality, followed by 0.44 closeness centrality along with 6.56 betweenness centrality and eigenvector of -46.117. Takahashi K stands third on the ranking in collaboration with degree of centrality 15.704, followed by 0.44 closeness centrality along with betweenness centrality 2.936 and eigenvector -29.524.

38. In Animal Biotechnology, Lawrence B. Schook has produced highest number of collaborated articles with 20.896 degree of centrality followed by closeness centrality of 1.449 along with 6.344 betweenness centrality and -47.769
eigenvector. B. P. Mishra stands second in author collaboration with 15.672 degree of centrality, followed by 0.877 closeness centrality along with 1.252 betweenness centrality and eigenvector of 0. Jonathan E. Beever stands third on the ranking in collaboration with degree of centrality 15.672, followed by 0.877 closeness centrality along with betweenness centrality 1.252 and eigenvector 0.

39. In Bioscience, Biotechnology and biochemistry, Takahashi K has produced highest number of collaborated articles with 20.896 degree of centrality followed by closeness centrality of 1.449 along with 6.344 betweenness centrality and -47.769 eigenvector. Kimura T stands second in author collaboration with 16.981 degree of centrality, followed by 0.986 closeness centrality along with 8.828 betweenness centrality and eigenvector of 52.266. Nakamura Y stands third on the ranking in collaboration with degree of centrality 15.672, followed by 0.877 closeness centrality along with betweenness centrality 1.252 and eigenvector 0.

40. In Biotechnology and Bioprocess Engineering, Young Je Yoo has produced highest number of collaborated articles with 10 degree of centrality followed by closeness centrality of 0.481 along with 0.805 betweenness centrality and 0 eigenvector. Kye-Yong Song stands second in Institute –wise collaboration with 9.13 degree of centrality, followed by 0.49 closeness centrality along with 0.584 betweenness centrality and eigenvector of 49.601. Moon-Sik Yang stands third on the ranking in collaboration with degree of centrality 8.696, followed by 0.526 closeness centrality along with betweenness centrality 1.294 and eigenvector 0.

41. In Biotechnology Advances, R.B. Gasser has produced highest number of collaborated articles with 16.981 degree of centrality followed by closeness centrality of 0.986 along with 8.828 betweenness centrality and 52.266 eigenvector. B.E. Campbell stands second in author collaboration with 13.208 degree of centrality, followed by 0.985 closeness centrality along with 2.249 betweenness centrality and eigenvector of 55.337. Alex Loukas stands third on the ranking in author collaboration with degree of centrality 10.063, followed by 0.985 closeness centrality along with betweenness centrality 2.169 and eigenvector 41.542.
42. In Current Opinion in Biotechnology, Willem M de Vos has produced highest number of collaborated articles with 22.353 degree of centrality followed by closeness centrality of 1.95 along with 12.297 betweenness centrality and 6.457 eigenvector. Michael E Himmel stands second in Institute-wise collaboration with 18.824 degree of centrality, followed by 1.944 closeness centrality along with 5.042 betweenness centrality and eigenvector of 60.029. Jay D Keasling stands third on the ranking in collaboration with degree of centrality 17.647, followed by 1.934 closeness centrality along with betweenness centrality 8.711 and eigenvector 0.

43. In Food Biotechnology, Kalidas Shetty has produced highest number of collaborated articles with 50 degree of centrality followed by closeness centrality of 51.429 along with 68.519 betweenness centrality and 26.415 eigenvector. Robert E. Levin stands second in author collaboration with 47.222 degree of centrality, followed by 50 closeness centrality along with 5.042 betweenness centrality and eigenvector of 60.029. E. Apostolidis stands third on the ranking in collaboration with degree of centrality 19.444, followed by 36.364 closeness centrality along with betweenness centrality 0.661 and eigenvector 14.297.

44. In Food Technology and Biotechnology, Ashok Pandey has produced highest number of collaborating articles with 19.713 degree of centrality followed by closeness centrality of 1.166 along with 19.146 betweenness centrality and 61.386 eigenvector. Carlos Ricardo Soccol stands second in author collaboration with 14.695 degree of centrality, followed by 1.161 closeness centrality along with 3.102 betweenness centrality and eigenvector of 55.011. David Mitchell stands third on the ranking in collaboration with degree of centrality 11.111, followed by 1.147 closeness centrality along with betweenness centrality 8.716 and eigenvector 0.

45. In Journal of Biotechnology, Alexander Goesmann has produced highest number of collaborated articles with 28.176 degree of centrality followed by closeness centrality of 0.44 along with 8.89 betweenness centrality and -49.813 eigenvector. Alfred Puhler stands second in author collaboration with 28.176 degree of centrality, followed by 0.44 closeness centrality along with 6.56 betweenness centrality and eigenvector of -46.117. Andreas Tauch stands third on the ranking in collaboration with degree of centrality 15.704, followed by 0.44 closeness centrality along with betweenness centrality 2.936 and eigenvector -29.524.
46. In Journal of Chemical Technology & Biotechnology, Dionissios Mantzavinos has produced highest number of collaborated articles with 12.108 degree of centrality followed by closeness centrality of 0.518 along with 1.535 betweeness centrality and 0 eigenvector. Derin Orhon stands second in author collaboration with 9.865 degree of centrality, followed by 0.495 closeness centrality along with 0.741 betweeness centrality and eigenvector of 0. A Amrane stands third on the ranking in collaboration with degree of centrality 8.52, followed by 0.488 closeness centrality along with betweeness centrality 0.427 and eigenvector 0.

47. In Journal of Industrial Microbiology and Biotechnology, Jian Chen has produced highest number of collaborated articles with 12.442 degree of centrality followed by closeness centrality of 0.526 along with 0.945 betweeness centrality and 0 eigenvector. Guocheng Du stands second in author collaboration with 9.217 degree of centrality, followed by 0.526 closeness centrality along with 0.318 betweeness centrality and eigenvector of 0. M. A. Cotta stands third on the ranking in collaboration with degree of centrality 7.834, followed by 0.5 closeness centrality along with betweeness centrality 0.2 and eigenvector 41.073.

6.3 Suggestions for Further Research

Based on the present study, the following areas are identified for further research.

- The present study involved only ten Biotechnology journals of Biotechnology for Social Network Analysis of author collaboration. Future study may concrete on reasons favouring of collaboration among authors.
- A comparative study of Biotechnology literature along with other subject literature can be carried out.
- The same study can also be carried for other journals of Biotechnology literature.
- A study concerting only country-wise collaboration can also be made.
- A comparative study on male and female ego-network analysis can be made
- Studies on the area-wise collaboration within Biotechnology journals can be carried out.
6.4 Conclusion

This study has provided deep insight of author collaboration in Biotechnology journals for ten years. The data collected from web of science of Biotechnology were analysed for scientometric criteria covering the growth of literature over years which is statistically proved that there is progressive growth in number of articles in Biotechnology journals. The most preferred mode or form of scholarly communication in journals by Biotechnologist is research articles than other forms like reviews, proceedings etc. The analysis of country-wise and institute—wise reveals that developed countries are high at research articles in Biotechnology. The authorship trend in Biotechnology is not different from previous research results i.e. increase in the growth of multi-authored articles compared to single authored articles. The study also revealed the degree of collaboration among authors in multi-authored articles; even this study supported the lotka’s law. The statistical study also nullified that lotka’s law doesn’t fit to literature of Biotechnology journals. The collaboration in Biotechnology is very eminent in all the ten journals supporting the hypothesis that there is increase in multi-authored articles in Biotechnology.

The Social Network Analysis reveals that there is constant growth of collaboration among Biotechnology authors in terms of producing better results through research articles. The SNA also overcomes the drawback of scientometric study by in depth analysis of author collaboration as well as it gives more insights on the strength and weakness of bonding between authors of Biotechnology community, it also shows the collaboration between countries and institutes through which collaborating agents are identified at both macro and micro level. The results also shows that the Biotechnology community is well connected and it fits to small world phenomenon.

The author collaboration varies from journal to journal and year to year reflecting the factors affecting collaboration, the reasons behind establishment of collaboration between Biotechnologists has to be psychologically studied. The reveals there is power law distribution among authors of Biotechnology, the reasons behind this are many as revealed in previous like research guide and student relation, position of collaborating author, research head and scientists in R&D’s etc. the findings of study will help to understand the collaboration among Biotechnologist helps in policy making of Libraries and Research and Development policies.