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REFERENCE CURVE FOR INDIAN ROLE MODEL SCIENTIST*

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ABSTRACT

A database on eminent Indian role model scientists (Homi Jehangir Bhabha, Pushpa Mittra Bhargava, Chittranjan R. Bhatia, Satyendra Nath Bose, Rajagopala Chidambaram, Virendra Lal Chopra, Padmanabha Krishnagopala Iyengar, Ramaswamy Hariharan Iyer, Shyam Sunder Kapoor, Kariamanikkam Srinivasa Krishnan, Prasanta Chandra Mahalanobis, L.L. Narayana, Jayant Vishnu Narlikar, Chandrashekhar Venkata Raman, Raja Ramanna, K. Ramiah, Ram Gopal Rastogi, G.M. Reddy, Vinodini Reddy, Meghnad Saha, Vikram Ambalal Sarabhai, Monkombu Sambasivan Swaminathan and C.S. Venkata Ram) was created with their number of publications during five-year periods starting from the first publication year, and it was processed for their central tendencies, in order to develop the quadratic equation employing: $\sum Y_i = an + b\sum X_i + c\sum X_i^2$, $\sum X_iY_i = a\sum X_i + b\sum X_i^2 + c\sum X_i^3$; *and* $\sum X_i^2Y_i = a\sum X_i^2 + b\sum X_i^3 + c\sum X_i^4$ *(where* X_i *and* Y_i *are the observed year and cumulative publications respectively; and a, b, and c are constants of the fitted equation* $y=a+bx+cx^2$ *) to better fit a reference curve of expected values. Median values gave the best curve fit. Quinquenniumwise (Q) number of publications expected in the median of Indian role model scientist are: QI=11, QII=17, QIII=19, QIV=20, QV = 22, QVI =22, QVII=23, and QVIII=25.*

Keywords: Scientometrics; Bio-bibliometrics; History of science; Sociology of science; Role model scientists; Reference national role model scientist; Developing countries; Reference curve fitting; Publication productivity; Science of science

INTRODUCTION

Krishna (1991) propounded vaguely that "most of the developing countries lack local 'role models' to motivate other scientists". In order to understand the multidimensional aspects of this problem, consistent efforts were directed towards scientometric analysis of reputed Indian scientists (Kademani, Kalyane

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* *This paper is dedicated to Homi Jehangir Bhabha*

and Balakrishnan, 1994; Kademani, Kalyane and Kademani, 1994; Kademani and Kalyane, 1996a; Kademani and Kalyane, 1996b; Kademani, Kalyane and Kademani, 1996a; Kademani and Kalyane, 1998; Kademani, Kalyane and Kumar, 2000; Kalyane, 1992; Kalyane and Kalyane, 1993; Kalyane, 1994; Kalyane and Kalyane, 1994; Kalyane and Devarai, 1994; Kalyane and Kademani, 1994; Kalyane, 1995; Kalyane and Samanta, 1995; Kalyane and Kademani, 1995; Kalyane, 1995; Kalyane and Sen, 1998) and a scientist of Indian origin (Kademani, Kalyane and Kademani, 1996b). Similar scientometric portraits on a few foreign scientists (Kademani, Kalyane and Jange, 1999; Kalyane and Munrolli, 1995; Kalyane and Sen, 1996, Kalyane and Kademani, 1997) were also published. Database on a single research institute was well documented (Kalyane and Kalyane, 1991; Kalyane and Vidyasagar, 1992, Kalyane and Kalyane, 1994b; Kalyane and Kalyane, 1996), and it was demonstrated that studies on single journal (Kalyane and Sen, 1995) or a single topic (Kalyane, 1993; Venkataramana, Kalyane and Munnolli, 1994) can also highlight contributions of scientists of the country.

Objectives of the present study are:

(a) to calculate central tendencies on the number of observed publications by Indian role model scientists per quinquennium;
(b) to develop quadratic equations useful for the estimation of the expected values through curve fitting; and
(c) to plot the observed and the estimated values in a growth curve.

MATERIALS

The present pilot study observes the publication productivity of the following Indian role model scientists: C.V. Raman, K. Ramiah, S.N. Bose, P.C. Mahalanobis, Meghnad Saha, K.S. Krishnan, H.J. Bhabha, and Vikram Sarabhai, who had their first publication during India's pre-independence era; aswell as P.M. Bhargava, Raja Ramanna, M.S. Swaminathan, C.S. Venkata Ram, R.G. Rastogi, P.K. Iyengar, L.L. Narayana, R. Chidambaram, V.L. Chopra, R.H. Iyer, Vinodini Reddy, C.R. Bhatia, S.S. Kapoor, Jayant Narlikar and G.M. Reddy, who had started their lives as scientists and their first publication were published during India's post-independence period.

METHODS

Indian role model scientists were randomly selected in order to include all diversified research domains (see Appendix). It is assumed that their scientific career begins (origin year) with the first research publication authored independently or in collaboration to enable batch-processing of the five yearly (quinquennial) output of observations on number of publications by each scientist under consideration. The database generates the normal count procedure (Kalyane and Vidyasagar Rao, 1995), where one full score credit is given, for each author regardless of their first or last position in the byline.

Central tendencies were calculated based on observed data for the number of publications per quinquennium. A statistical average (mean) of data values is calculated by dividing the sum of all values by the number of values. The mean value typifies a set of numbers. The mean m for n values is calculated by the formula:

$$m = \frac{\sum_{i=1}^{n} x_i}{n}$$

The mode is the most frequently occurring number of a set of numbers. The median is useful when extreme values in the data distort the mean or the average. The median is determined by ranking the data values in ascending or descending order and then selecting the middle value, specifically, the quantity or value of that item is so positioned in the series, that there are equal number of items of greater magnitude and lesser magnitude. A mathematical curve was fitted to arrive at the estimated values.

Curve Fitting Theory

Let the observed data be $\{X_i, Y_i\}$. It is fitted to a quadratic equation $y = a+bx+cx^2$ where, a, b, and c are constants. The number of observed data points (n) should exceed two to enable the curve fitting procedure. In practice n should be considerably large. Let the sum of error squares be S.

$$S = \sum e_i^2 = \sum (a + bX_i + cX_i^2 - Y_i)^2$$

The following equations were obtained by partial differentiation with respect to a, b, and c.

$$S_a = \sum 2 (a + bX_i + cX_i^2 - Y_i)$$

$$S_b = \sum 2 (a + bX_i + cX_i^2 - Y_i) X_i$$

$$S_c = \sum 2 (a + bX_i + cX_i^2 - Y_i) X_i^2$$

Setting the partial derivatives to zero and simplifying we get three equations with three unknowns as follows:

$$\sum Y_i = a\,n + b \sum X_i + c \sum X_i^2$$
$$\sum X_i Y_i = a \sum X_i + b \sum X_i^2 + c \sum X_i^3$$
$$\sum X_i^2 Y_i = a \sum X_i^2 + b \sum X_i^3 + c \sum X_i^4$$

The above simultaneous equations can be solved by methods like Gauss-Jordan.

Application of the Curve Fitting Theory

It is assumed that there are zero publications prior to the first paper publication year of any individual scientist. This is realistic as one has to pass through a latent phase of conducting research prior to the observable event of the first publication in order to prove ones worth as a scientist. After curve fitting by using the above realistic data, the first value at zero years was removed for further calculations by retaining the rest of the actually observed data (Dodes and Greitzer, 1964 and Singer, 1964).

RESULTS AND DISCUSSION

Table 1 documents the observed and estimated mean, mode, and median number of publications by a random sample of Indian role model scientists. The table has rounded up figures for both the observed and estimated values. The estimated values were obtained by a quadratic equation fit to nine periods, each of five years (quinquennium) duration. The constants a, b, and c had high precision.

Table 1: The Mean, Mode and Median Number of Publications Published by the Indian Role Model Scientists

Years	Mean		Mode		Median	
	Observed	Estimated	Observed	Estimated	Observed	Estimated
5	10.83	12.34	11	15.37	10	10.52
10	26.09	34.98	31	41.42	21	28.34
15	49.70	59.33	59	67.42	41	47.29
20	83.53	85.40	93	93.38	65	67.36
25	120.44	113.18	126	119.29	94	88.56
30	153.13	142.69	159	145.15	120	110.88
35	182.09	173.90	174	170.97	139	134.32
40	194.26	206.84	186	196.73	150	158.90

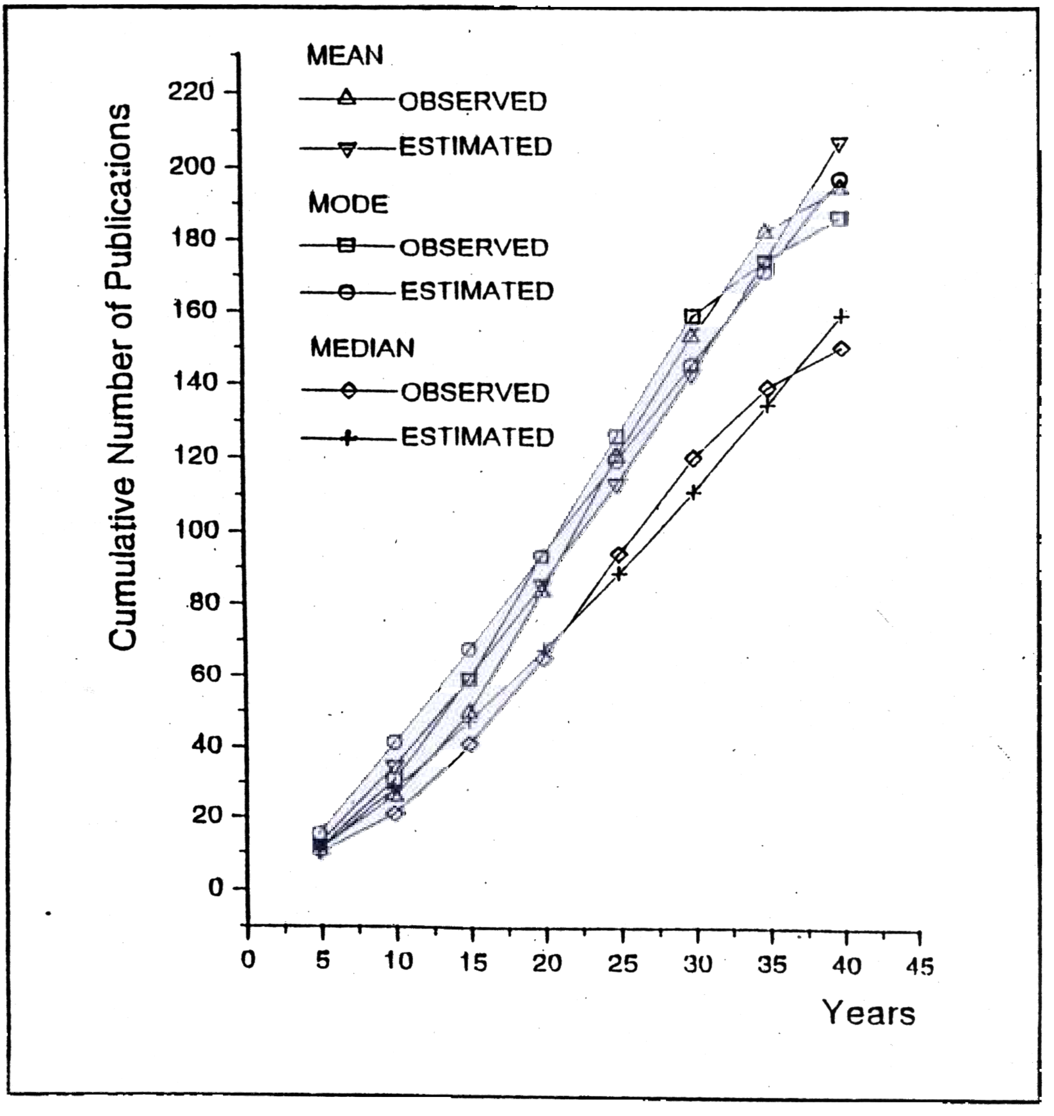
Table 2 gives the constants a, b, and c for each central tendency with precision up to the second decimal place.

Table 2: Parameters of the Fitted Equation for the Indian Role Model Scientists

Central Tendencies	Constants		
	a	b	c
	-27.78	18.35	0.86
Mode	-36.88	26.17	-0.024
Median	-21.74	15.01	0.56

The values of a, b, and c can be used in the proposed equations to compare the performance of an individual Indian scientist. The cumulative values of the observed and expected central tendencies from Table 1 were used for graphical representation and shown in Figure 1

Figure 1: Mean, Mode and Median Number of Publications by Indian Role Model Scientists



Of the three central tendencies considered, it was observed that the median curve displayed the least fitting error. It is therefore suggested that the observed values of an Indian scientist's productivity be compared with the estimated values of the median. If his/her performance compares favourably with the estimated median values, then the scientist may be considered as following an Indian role model scientist. This is taken as the most simplified version of the complex relationship between science, scientist and the contemporary scientific society.

Suggestions

A researcher is considered good if he or she surpasses the expectations of what he or she might achieve. But this is only possible if the focus is on work and the problems involved, and not on competition or success. The effectiveness of research or of running an institution depends primarily on the researcher himself, on his models, the environment within the institute itself, and on the respect he shows his staff members, which, in turn, enables him to demand that they work to capacity (Maier - Leibnitz, 1992). Scientists of all disciplines should learn from the humanities.

In a personal correspondence West (1995) expressed,

> "The only factor I can think of that to a great extent dictates the work rate and the nature of publication of scientists, which you have not mentioned is the nature of their employment and the different environments in which they may work from time to time. For example, at an early age in academe while they are finding their way in research, and deciding which routes they will follow, their publication rate is likely to be lower than when they have established these factors. By the time they have reached mid career they may well have been forced by the economics of doing research to spend much of their otherwise productive time chasing funding organizations for money for equipment and research grants for postgraduate or postdoctoral co-workers. Yet again, later in their career they may have transferred from University to State or National Research Institute where for example, reasons of confidentiality or other considerations such as national security, increasing administrative responsibility and so on, it may become increasingly difficult for them to publish or even to keep up with the accelerating pace of innovation in technology and even in some cases new scientific concepts.
>
> Then of course much depends on the country in which they can or are able to do their work. I believe for example that it was much easier to do research in my country (UK) than in yours (India). Also, I believe that it was easier to do reasonably good research in the 60's than in the 80's in the UK and in many other technologically advanced countries. This was due to public and governmental perceptions of the role that science had to play in the community. On the other hand in the 70-90's the increasing availability of computational facilities, microelectronics, communication, etc. (and advances in technology generally) made advances easier than previously.
>
> However, I have to say that I do not know how it may be possible (if at all) even to quantify for such criteria in order to compare 'productivity'

> or 'scientific capability' so that such factors may be taken into account in comparative assessment of individuals working in different sciences, different eras and different communities".

The duty of scientists and technologists is not only to conduct their own work at the highest possible level of quality but also to make the societies in which they live more aware of the powers and climate of science. Since, by definition, scientists and technologists are the first to know of scientific advances, they can be described as the cartographers of the future. They must work to ensure that the public, and especially the public's leaders, understand the maps they draw and the options that are available and sustainable, so that wise democratic decisions can be taken (Dainton, 1992).

Forecasting

The proposed method has applications and implications in forecasting. If young Indian scientists has shown promise by following at least the median estimated curve for the first three quinquennia, then the scientists has potential to become role model scientists. Hence, such scientists should be identified and nurtured to enable them to excel by outperforming their own past record and possibly surpassing the records of previous role models of the country. Thus, there is a dynamic performance scope incorporated in the model for future considerations.

Limitations

It is assumed that publication productivity of a role model scientist motivates younger colleagues to collaborate or emulate. The present pilot study is limited to only Indian role model scientists and their quantitative outputs of publications, may be only one of the many possible factors that motivate young scientists. However, the number of publications still remains possibly the most important measurable parameter. One of the first writers to suggest the number of research papers as a scientific measure of research productivity was Nobel laureate Shockley (1957). Confidential research efforts remain unpublished and hence, unobserved in the present study. Presently, there is no recommended method to quantify the time and efforts involved in developmental activities such as, organising research facilities, research planning, research management, teaching, etc., as equivalent to a research publication. Therefore, the scientists engaged in developmental activities (fully or simultaneously) are not visible on publication records.

Similar to the 80/20 rule (Egghe, 1986), the focus of the present study is on the 20 percent of the scientists who contribute up to 80 percent of the total research productivity in an organisation. Perhaps no number of motivator(s) will be enough to motivate about 80 percent of the scientists who contribute only 20 percent of the total publication productivity. Voltaire remarked that, "even if God did not exist, it would be necessary to invent Him". To this statement, Pandit Jawaharlal Nehru responded that "there is something also in the reverse proposition: even if God exists, it may be desirable not to look up to Him or to rely upon Him". (Kalyane and Samanta, 1993).

So far motivation theories propounded by Maslow (1954), Herzberg et al.(1959), McGregor (1960), Vroom (1964), French, et al. (1965, 1966), Likert (1967), Basset and Mayer (1968), Porter and Lawler (1968), Smith and Cranny (1968), Lowin (1968), Locke (1970), Lyons (1971), have unconsciously neglected the exemplary role model as a source of inspiration and motivation. Moreover, role model exemplar performance as an input to inspire and motivate does not require any financial commitments on the organisation. What is required is to show that if your colleague can do it, you too can do it, perhaps in a better way. This can be called as "show how of the know how". This is exactly the situation where we need the 'local role model' concept.

Biographies and autobiographies have influenced many individuals generation after generation. For that matter, even imaginary characters in a play, drama, and novel also influence thought process as well as a source of motivation. It is therefore natural that the number of papers published in national or international channels of communication constitutes the major output of the life of a scientist, as science is an ever flowing and continuous process of knowing the truth. Hence, this area of how 'local role model scientist' can promote research productivity needs further research.

Proposal

(a) Further research is necessary to establish the equivalent (conversion factors) of a quantum of developmental activity with a research publication.
(b) Quality aspects (citation data, citer motivation, peer review, etc.) may be incorporated in the research evaluation.
(c) Developing countries having similar science and technology status and goals may be identified, and it may be interesting to explore the possibilities of establishing a developing country regional role model reference scientist curve.

CONCLUSION

The present pilot study has indicated that it is possible to develop a model on the performance of a role model scientist of a country. Every developing country has her own priorities and protocols of research and development. Hence, each country should develop its own role model. There are many role models in developing countries. What is lacking is a proper documentation and systematic study on them. Every developing country should develop their own national level science and technology indicators and scientometric database to record facts about the past, present and future research undertakings. This kind of studies can have an impact on the scientific human resource development and National Science and Technology Policy.

Apart from that, the human resource has the capacity to produce and whose upper limits cannot be defined. The purpose of the present paper will be fulfilled if it can sensitise scientists from developing countries, especially Indian scientists to surpass/excel the excellent role models of the country. The concept of the role model has to be dynamic in order to cater to the current and future national demands.

REFERENCES

Basset, G.A. and Meyer, H.H. 1968. Performance appraisal based on self-review. *Personel Psychology*, Vol. 2 (Winter): 421-430.

Dainton, Lord. 1992. Knowledge is our destiny. *Interdisciplinary Science Reviews*, Vol. 17, no.2: 116-119.

Dodes, L.A. and Greitzer S.L. 1964. *Numerical analysis.* NY: Hayden Book.

Egghe, L 1986. On the 80/20 rule. *Scientometrics*, Vol.10, no.1-2: 55-68

French, J.R.P.; Kay, E.; and Meyer, H.H. 1965. Effects of threat in a performance appraisal interview. *Journal of Applied Psychology*, Vol.49: 311-17.

French, J. R. P.; Kay, E.; and Meyer, H.H. 1966. Participation and the appraisal system. *Human Relations*, Vol.19 (Feb): 3-19.

Herzberg, Frederick; Mausner, Bernard; and Snyderman, Barbara Bloch 1959. *The Motivation to work.* New York : John Wiley & Sons.

Kademani, B.S. and Kalyane, V.L. 1996a. Bibliometric indicators for publication productivity analysis of an individual scientist. *JISSI: The International Journal of Scientometrics and Informetrics*, Vol.2, no.4: 49-58.

Kademani, B.S. and Kalyane, V.L. 1996b. Outstandingly cited and most significant publications of R. Chidambaram, a nuclear physicist. *Malaysian Journal of Library & Information Science,* Vol. 1, no.1: 21-36.

Kademani, B.S. and Kalyane, V.L. 1998. Scientometric portrait of R. Chidambaram, the Indian nuclear physicist, based on citation analysis. *Kelpro Bulletin*, Vol.2, no.1: 13-29.

Kademani, B. S.; Kalyane, V. L. and Balakrishnan, M.R. 1994. Scientometric portrait of P. K. Iyengar. *Library Science with a Slant to Documentation and Information Studies*, Vol.31, no.4: 155-176.

Kademani, B.S.; Kalyane, V.L. and Kademani, A.B. 1994. Scientometric portrait of Nobel laureate Dr. C. V. Raman. *Indian Journal of Information, Library and Society*, Vol.7, no.3-4: 215-249.

Kademani, B.S. ; Kalyane, V.L. and Kademani, A.B. 1996a. Scientometric portrait of Nobel laureate S. Chandrasekhar. *JISSI: The International Journal of Scientometrics and Informetrics*, Vol.2, no. 2-3: 119-135.

Kademani, B.S.; Kalyane, V.L. and Kademani, A.B. 1996b. Scientometric portrait of Sir K. S. Krishnan. *Indian Journal of Information Library & Society*, Vol.9, no. 1-2: 126-150.

Kademani, B.S.; Kalyane, V. L. and Jange, Suresh. 1999. Scientometric portrait of Nobel laureate Dorothy Crowfoot Hodgkin. *Scientometrics*, Vol. 45, no.2: 233-250.

Kademani, B.S. ; Kalyane, V.L. and Vijai Kumar. 2000. Scientometric portrait of Vikram Ambalal Sarabhai: A citation analysis. *SRELS Journal of Information Management*, Vol.37, no.2: 107-132.

Kalyane, V.L. 1992. Dr. M. S. Swaminathan - Biologist par excellence. *Biology Education*, Vol.9, no.3: 246-248.

Kalyane, V.L. 1993. Informetrics on *Neem* research in India. *Library Science with a slant to Documentation and Information Studies*, Vol.30, no.4: 139-145.

Kalyane, V.L. 1994. Establishing scientometric database for harnessing expertise and information sources. *International Information, Communication and Education*, Vol.13, no.2 : 208-212.

Kalyane, V.L. 1995a. Role model scientist. *Whither Indian Science, Third National Convention on "What is Wrong with Indian Science"* New Delhi : Indian Science Writers' Association: 31-34.

Kalyane, V.L.1995b. Scientometric portrait of P.M. Bhargava. *Lucknow Librarian*, Vol.27, no.1- 4: 42-70.

Kalyane, V. L. and Devarai, Rajashekar S. 1994. Informetrics on C. S. Venkata Ram. In : ed. C. P. Vashishth; L. S. Ramaiah; N. V. Jaggarao and T. V. Prafulla Chandra. *New Horizons in Library and Information Science: Dr. Velaga Venkatappaiah Festschrift.* Madras: T. R. Publications: 475 - 478.

Kalyane, V.L. and Kademani, B.S. 1994. Scientometric portrait of U.R. Murty. *LIBCON-94 National Conference on Bibliometrics, Informetrics and Scientometrics.* Bangalore : State Youth Librarians Association: 48.

Kalyane, V.L. and Kademani, B.S. 1995. Scientometric portrait of R. Chidambaram: A publication productivity analysis. *Journal of Information Sciences.* Vol.5, no.3: 101-140.

Kalyane, V.L. and Kademani, B.S. 1997. Scientometric portrait of Barbara McClintock: The Nobel laureate in physiology. *Kelpro Bulletin*, Vol. 1, no.1: 3-14.

Kalyane, V.L. and Kalyane, S.V. 1991. Scientometric dimensions of innovation communication productivity system. *Annals of Library Science and Documentation*, Vol. 38, no.1: 8-29.

Kalyane, V.L. and Kalyane, S.V. 1993. Scientometric portrait of Vinodini Reddy. *Journal of Information Sciences*, Vol.4, no. 25- 47.

Kalyane, V.L. and Kalyane, S.V. 1994a. R&D communication strategy *vis-à-vis* librarianship. *Journal of Information Sciences*, Vol.4, no.2: 105-135.

Kalyane, V.L. and Kalyane, S.V. 1994b. Scientometric portrait of M.S. Swaminathan. *Library Science with a slant to Documentation and Information Studies*, Vol.31, no.1: 31-46.

Kalyane, V.L. and Kalyane, S.V. 1996. Database on creativity and innovation communication productivity of science in India : A case study. *Journal of Information Sciences*, Vol.7, no.1: 3- 44.

Kalyane, V.L. and Munnolli, S.S. 1995. Scientometric portrait of T.S. West. *Scientometrics*, Vol.33, no.2: 233-256.

Kalyane, V.L. and Samanta , R.K. 1993. Religious dogmas, scientific temper and society. *Science Courier*, Vol.4, no.5 : 4 -11.

Kalyane, V.L. and Samanta, R. K. 1995. Informetrics on K. Ramiah. In: ed. A. A. N. Raju; L.S. Ramaiah; N. Laxman Rao and T.V. Prafulla Chandra. *New Vistas in Library and Information Science : papers in Honour of Professor G. V. S. L. Narasimha Raju.* New Delhi : Vikas Publishing House : 565 -578.

Kalyane, V.L. and Sen, B.K. 1995. A bibliometric study of the *Journal of Oilseeds Research*. *Annals of Library Science and Documentation*, Vol. 42, no.4 : 121-141.

Kalyane, V.L. and Sen, B.K. 1996. Scientometric portrait of Nobel laureate Pierre-Gilles de Gennes. *Malaysian Journal of Library & Information Science*, Vol.1, no.2: 13-26

Kalyane, V.L. and Sen, B.K. 1998. Scientometric portrait of C.R. Bhatia. *Malaysian Journal of Library & Information Science*, Vol. 3, no.1: 25-42.

Kalyane V.L. and Vidyasagar Rao K. 1992. Collaboration trends in sugarcane research- A case study. *Annals of Library Science and Documentation*, Vol.39, no.1: 9-11.

Kalyane, V.L. and Vidyasagar Rao K. 1995. Quantification of credits for authorship. *ILA Bulletin*, Vol.30, no.3-4: 94-96.

Krishna, V.V. (Reviewer) 1991. Book Review; *Scientists in the Third World*. Gaillard, Jacques. 1991. Lexington, Ky USA. *Journal of Scientific and Industrial Research*, Vol.50, no.6: 463-66.

Likert, Rensis. 1967. *The human organization*. New York Mc Graw - Hill Book Co.

Locke, Edwin A. 1970. Job satisfaction and job performance : A theoretical analysis. *Organizational Behaviour and Human Performance*, Vol.5 (Sept.): 484-500.

Lowin, Aaron. 1968.Participative decision making: A model, literature critique, and prescriptions for research. *Organizational* Behaviour *and Human Performance*, Vol. 3(Feb.): 68 –106.

Lyons, T.F. 1971. Role clarity, satisfaction, tension and withdrawal. *Organizational Behaviour and Human Performance*, Vol.6 (Jan): 99-110.

Maier – Leibnitz, Heinz. 1992. Science and the humanities-A plea for interdisciplinary communication. *Interdisciplinary Science Reviews*, Vol.17, no.2 : 171-177.

Maslow, Abraham H. 1959. *Motivation and personality*. New York Harper & Bros.

McGregor, Douglas. 1960. *The human side of enterprise*. New York McGraw – Hill Book Co.

Porter, Lyman W. and Lawler, Edward E., III. 1968. *Managerial attitudes and performance*. Homewood, Ill. : Richard D. Irwin, Inc.

Shockley, W. 1957. On the statistics of individual variations of productivity in research laboratories. *Proceedings of the IRE*, (March) : 279 – 290.

Singer, James. 1964. *Elements of numerical analysis*, NY: Academic Press.

Smith, Patricia Cain and Cranny, C. J. 1968. Psychology of men at work. *Annual Review of Psychology*, Vol. 19: 467 – 496.

Venkataramana, P. ; Kalyane, V.L. and Munnolli, S. S. 1994. Informetrics on mushrooming growth of mushroom research in India. *LIBCON-94 National Conference on Bibliometrics, Informetrics and Scientometrics.* Bangalore: State Youth Librarians Association : 44.

Vroom, Victor H. 1964. *Work and motivation.* New York : John Wiley & Sons.

West, T.S. 1995. Personal communication. In : Kalyane V. L. 1996. *Role Model for Modern Biology Students*, Project work ES - 305 - Post Graduate Diploma in Higher Education; New Delhi : School of Education, Indira Gandhi National Open University, 311-312.

APPENDIX

Bhabha, Homi Jehangir: Cosmic rays; Theory of elementary particles and Mathematical Physics; Bhabha-Heitler cascade theory; Bhabha scattering; Nomenclature 'meson' for the particle of intermediate mass discovered in cosmic radiation, meson theory, the test of relativistic time dilation involving meson lifetime; Utilised group theory to formulate relativistic wave equations ; for elementary particles - Bhabha equation.

Bhargava, Pushpa Mittra: Reproductive Biochemistry; Liver cell suspension and uptake of Nucleic acids; Cell division; Organic Chemistry and insecticides; Evolution; Antarctic Microbiology; Protein denaturation; tRNA and rRNA

Bhatia, Chittranjan R.: Induced mutations and mutation breeding; Seed Proteins; Biotechnology; Biochemical Genetics; Plant Breeding

Bose, Satyendra Nath : Radiation Theory; D^2- Statistics; Electromagnetic waves in ionosphere; Extraction of germanium; The principle of Relativity; Deduction of Rydberg's law from the quantum theory of spectral emission

Chidambaram, Rajagopala: Nuclear Magnetic Resonance; Neutron Diffraction & Hydrogen bonding; High Pressure & Shock Wave Physics; Quasi Crystals

Chopra, Virendra Lal : Experimental mutagenesis; Disease Resistance in wheat; Biotechnology of oilseeds and chickpea; Breeding wheat varieties DL 20-9 (northern zone) and HW 657 (peninsular zone); Indigenous technology for producing stable and cost-effective cellular bio-pesticides based on mutations of the toxic Bt gene

Iyengar, Padmanabha Krishnagopala : Neutron and Solid State Physics; Mossbaur Spectroscopy; Reactor Physics; Fusion, and Cold fusion; Nuclear Power
Iyer, Ramaswamy Hariharan : Radioanalytical Chemistry; Radioisotopes
Kapoor, Shyam Sunder : Nuclear Physics; Nuclear Radiation detectors; Accelerator-based R&D; Accelerator Physics and energy dispersive X-ray fluorescence analysis of materials; Nuclear fission and superheavy elements in the country; BARC - TIFR pelletron accelerator
Krishnan, Kariamanikkam Srinivasa : Spectroscopy; Magnetism; Thermionics
Mahalanobis, Prasanta Chandra: Statistic-Mahalanobis Distance; Operations Research; Education Tests; Errors in Field Experimentations; Large-scale Sample Surveys; Perspective planning
Narayana, L. L.: Chemotaxonomy; Floral-anatomy, embryology, morphology; Taxonomy
Narlikar, Jayant Vishnu: Interpretation of cosmological observations; High Energy Astrophysics; Quantum cosmology; General relativity; Gravitation; Action-at-a distance electrodynamics conformal theory of gravity; Quasor Astronomy; A different approach to cosmology from a static universe through the big bang towards reality
Raman, Chandrashekhar Venkata: Scattering of light; Acoustics; Optics, Optics of minerals and diamonds; Physics of Crystals; Floral colours and visual perception
Ramanna, Raja: Nuclear physics; Nuclear Power and other peaceful uses of Atomic Energy; Reactor theory, Physics and design; Science general; Philosophy; European music; Variable Energy Cyclotron.
Ramiah, K.: Rice Cytogenetics and Breeding
Rastogi Ram Gopal: Luni-solar activity and quite-time E and F region; Equatorial electric field and low and mid latitude ionosphere; Ionospheric E-region irregularities; Ionospheric F-region irregularities; Magnetic disturbance effects on the equatorial low and mid latitude ionosphere
Reddy, G. M.: Biochemical and physiological Genetics; Mutagenesis and Mutation Breeding; Tissue Culture and Somatic Cell Genetics
Reddy, Vinodini: Malnutrition among children; Vitamin A; Protein; Kwashiorkor; Immunology; Diarrhoea; Blindness; Vitamin D; Anemia; Vitamin E
Saha, Meghnad: Astrophysics and Spectroscopy; Nuclear Physics and Atomic Energy; National Problems
Sarabhai, Vikram Ambalal: Cosmic Rays; Science Policy and National Development; Management
Swaminathan, Monkombu Sambasivan: Cytogenetics and Genetics; Phylogenetics; Crop Improvement; Induced Mutations and Mutation Breeding
Venkata Ram, C. S. : Tea pathology; Blister blight; Fungicides; Plantation Crops.